Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix A

Cooling Water Intake Study Plan

September 1, 2000

Attachment 1—Model Parameterization, May 11, 2001

Attachment 2—Example *ETM* Calculation, June 26, 2001

Morro Bay Power Plant Modernization Project

Cooling Water Intake Study Plan

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1.0 INTRODUCTION

Duke Energy Morro Bay, LLC is proposing to repower and modernize the existing Morro Bay Power Plant (MBPP) by replacing older steam-turbine generators with combined-cycle combustion turbine generators. The project is located within the existing MBPP, 13 miles northwest of the city of San Luis Obispo in San Luis Obispo County, in an area that includes industrial facilities, commercial facilities, residences, and recreational beaches.

The project involves installation of two combined-cycle units and the retirement of existing Units 1 through 4. The project will utilize the existing seawater intake structure and discharge line for Units 1 through 4. With the installation of the new units, the design volume of intake cooling water and intake approach velocities will be significantly lower than the present facility design. Following completion of final facility designs, a table will be prepared summarizing cooling water intake system (CWIS) design and operating parameters necessary for the evaluation of the new CWIS entrainment and impingement effects.

Field studies are proposed to provide information to support the renewal of Duke Energy Morro Bay LLC's NPDES permit, to characterize the existing habitat in the vicinity of the MBPP, and to allow for a current assessment of compliance with intake "best technology available" (BTA) using federal 316(b) guidance (USEPA, 1976).

Three studies have been proposed to address the questions regarding entrainment and impingement effects: (1) an entrainment study (sampling in front of the intake), (2) a source water study (sampling at a station in the entrance to Morro Bay, sampling at two stations in the back bay area of Morro Bay, and sampling at an offshore station downcoast of the entrance to Morro Bay in Estero Bay), and (3) an impingement study.

To assess the potential impact of the project on the source water and receiving water aquatic resources, site-specific information is being collected on the composition and abundance of all fishes and selected macroinvertebrates that are entrained and impinged. Entrainment data will be used to estimate the entrainment by the intakes and estimate proportional entrainment of source water larval fishes and cancer crabs. Impingement data include the species composition, abundance, lengths, and weights of all impinged fishes, decapod crabs, cephalopod mollusks, and sea urchins. Impingement rates, biomass estimates, and length frequency analyses will be determined from these data.

In response to concerns expressed by the California Department of Fish and Game (CDFG), the megalopal stage of all species of cancer crabs and the European green crab (*Carcinus maenas*) will be identified and enumerated from all processed plankton samples.

1.1 Previous Cooling Water Intake Studies

Section 316(b) of the CWA (PL 92-500 and 95-217) requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact. To comply with this requirement, Pacific Gas and Electric Company (PG&E) submitted a 316(b) study plan in the mid-1970s. The study plan, based on state and federal 316(b) guidelines, was reviewed by several government agencies, including staffs of the Regional Water Quality Control Board (RWQCB), State Water Resources Control Board, CDFG, and the United States Environmental Protection Agency (USEPA). The RWQCB decided that site-specific studies documenting the numbers of organisms entrained or impinged were not required for the Morro Bay Power Plant. The RWQCB staff concluded that results of extensive entrainment studies that were to be conducted at the Moss Landing Power Plant were sufficient to provide a basis for extrapolation to MBPP. In addition, a weekly impingement monitoring study was conducted between July 1977 and December 1978 (PG&E, 1982) to further evaluate the MBPP cooling water intake system. Although no entrainment studies were conducted at this site, entrained organisms were expected to include the planktonic eggs and larvae of fishes and invertebrates of species that spawn in open coastal waters and Morro Bay, such as flatfishes, gobies, rockfishes, shiner perch, and cancer crabs.

1.2 Other Studies

Several studies on juvenile and adult fishes have been conducted in the vicinity of the Morro Bay Power Plant. Complete summaries of the methods and results of these studies will be included in the MBPP's Application for Certification (AFC) that will be submitted to the California Energy Commission. Studies were conducted in Morro Bay beginning in January 1986 through December 1970 to document the fish species that utilize Morro Bay and to determine the spatial distributions and seasonal differences of the fish community within the estuary (Fierstine et al., 1973). A large synoptic study of the MBPP thermal discharge from Units 1 through 4 was conducted in 1971 - 1972 (PG&E, 1973). As part of this thermal effects study, the fish populations in Estero Bay were surveyed to address questions about thermal effects on their distributions. Quarterly bag seine sampling was conducted in Morro Bay in November 1974, May and August 1975, and February 1976 to assess diel (24-hour) and seasonal variations in species abundance, composition, and diversity within the shallow water fish community of the bay (Horn, 1980). The CDFG presently conducts monthly or semimonthly otter trawl surveys of the Morro Bay estuary to monitor the abundance of adult and juvenile fish species important to the area's commercial and recreational fisheries. These surveys began in April 1992.

The species composition and abundance of Morro Bay fishes have remained relatively constant. Three previous studies of adult fishes at Morro Bay showed similar composition and abundance over a decade of sampling. Horn (1980) found a total of 11,627 fishes represented by 21 species that were captured in 36 seine hauls. Three species, topsmelt (*Atherinops affinis*), shiner perch (*Cymatogaster aggregata*), and Pacific staghorn sculpin (*Leptocottus armatus*) comprised 82 percent of the number of individuals caught. All three of these species were common in Fierstine et al.'s (1973) studies of Morro Bay fish populations. Topsmelt and shiner perch were also two of the top five species collected in PG&E's (1982) impingement studies. Other species common among these studies were plainfin midshipmen (*Porichthys notatus*) (missing in Horn's studies) and northern anchovy (*Engraulis mordax*). Fierstine et al. (1973) reported that 12 of the species he caught, which he considered resident species, occurred in at least 6 or more of their survey months. Another 26 species, which they reasoned were seasonal or occasional visitors, were collected in a single month.

1.3 Additional Information

Morro Bay supports an active fishing industry; commercial fishing boats deliver their catch to the Port of Morro Bay, party boats operate from the harbor, and recreational fishing occurs in the area. The CDFG maintains a database of all commercial landings in the state. The location where fishes have been caught is required on each landing receipt. Several sport fishing surveys have been conducted targeting the fishing efforts and success including creel surveys by Pacific States Marine Fisheries Commission (PSMFC) and CDFG. Both agencies also conduct ongoing studies of local party boat fleet catches. Complete summaries of these data will be included in the MBPP's Application for Certification (AFC) that will be submitted to the California Energy Commission.

2.0 ENTRAINMENT AND SOURCE WATER STUDIES

2.1 Study Purpose and Design

The purpose of the MBPP entrainment and source water studies is to supplement the evaluation of the potential impacts on populations of larval fishes and cancer crab megalops associated with modernizing the MBPP. The studies were designed to address the following questions:

- What are the species composition and abundance of larval fishes and cancer crabs entrained by the MBPP?
- What are the estimates of local species composition and abundance of entrainable larval fishes and cancer crabs in Morro Bay?
- What are the potential impacts of the power plant's cooling water system on larval fishes and cancer crabs?

Field data on the composition and abundance of potentially entrained larval fishes and cancer crab megalops will provide an estimate of the total number and types of these organisms passing through the power plant's cooling water intake system. Additionally, data collected on source water stocks of entrainable fish larvae and megalopal cancer crabs will allow for estimation of fractional losses due to entrainment. The entrainment data will be used, assuming 100 percent entrainment mortality, with data collected from the source water to assess the potential impact to fishery and cancer crab resources.

Individuals of introduced European green crab will also be identified and enumerated from all processed plankton samples addressing concerns about its abundance raised by the CDFG. Impact assessment will not be done for European green crabs.

2.2 Entrainment Sampling

This study was designed to quantify the composition and abundance of entrained larval fishes and cancer and European green crab (*Carcinus maenas*) megalops at MBPP. Planktonic fish eggs will not be sorted from samples. Although many marine fish eggs are described, the taxonomy remains difficult and is very time consuming.

Samples from in front of the MBPP intake (Station 2; Figure 2-1) are collected by towing a bongo frame with two 0.71 m-diameter openings each equipped with 335-µm mesh plankton nets and codends. The water volume filtered is measured by calibrated flowmeters mounted in the openings of the nets. Samples are collected over a continuous 24-hour period, with each period divided into six, 4-hour sampling cycles. The MBPP entrainment sampling will occur weekly until a consecutive year of data is collected. Two replicated tow samples using paired bongo nets are collected during each cycle. The samples in the bongo net are combined for a single tow replicate. The samples collected in the bongo net are combined for a single tow replicate. Samples are collected at a station located directly off of the intake structure (Station 2; Figure 2-1). Sample collection methods are similar to those developed and used by the California Cooperative Oceanic and Fisheries Investigation (CalCOFI) in their larval fish studies (Smith and Richardson, 1977). The bongo nets are lowered as close to the bottom as possible, based on a depth reading from an echosounder mounted on the boat. Once the nets are as close to the bottom as possible, the boat is moved forward and the nets retrieved at an oblique angle (winch cable at a 45 degree angle). The winch retrieval speed is maintained at approximately 1 ft/sec, after the correct angle on the tow line is achieved.

The target combined volume of water filtered by both nets is approximately 40 m^3 (20 m^3/net). The sample volume is checked when the nets reached the surface. If the sample volume is approximately double (80 m^3 total), indicating possible flowmeter failure, the sample is voided and the tow repeated. If the target volume is not collected, the oblique tow method is repeated until the targeted volume is reached. The nets are then retrieved from the water, and all of the sample is rinsed into the codends.

The contents of both nets are combined into one sample immediately after collection. The sample is placed into a labeled jar and is preserved in ethanol (ETOH). Preservation in ETOH will allow specimen identifications to be genetically validated, checked for age, and measured for growth studies should the need arise. Each sample is given a serial number based on the location, date, time, and depth of collection. In addition, that information is logged onto a sequentially numbered data sheet. The sample's serial number is used to track it through laboratory processing, data analyses, and reporting.

2.2.1 Entrainment Sampling Frequency

Entrainment surveys were scheduled to occur weekly and were collected at Station 2 (Figure 2-1) once per week from June 21, 1999 through August 9, 1999. Tidewater goby, a federally listed endangered species, were collected in Survey 2 (June 28, 1999) and were identified and confirmed in early August 1999. The U.S. Fish and Wildlife Service (USFWS) and the CDFG were immediately notified regarding the collection of tidewater gobies. Source water and entrainment sampling was suspended, at their direction, because we did not possess a permit to allow for the destructive sampling of the tidewater goby. A USFWS Endangered Species Recovery Permit Application to allow for the collection of the goby was filed.

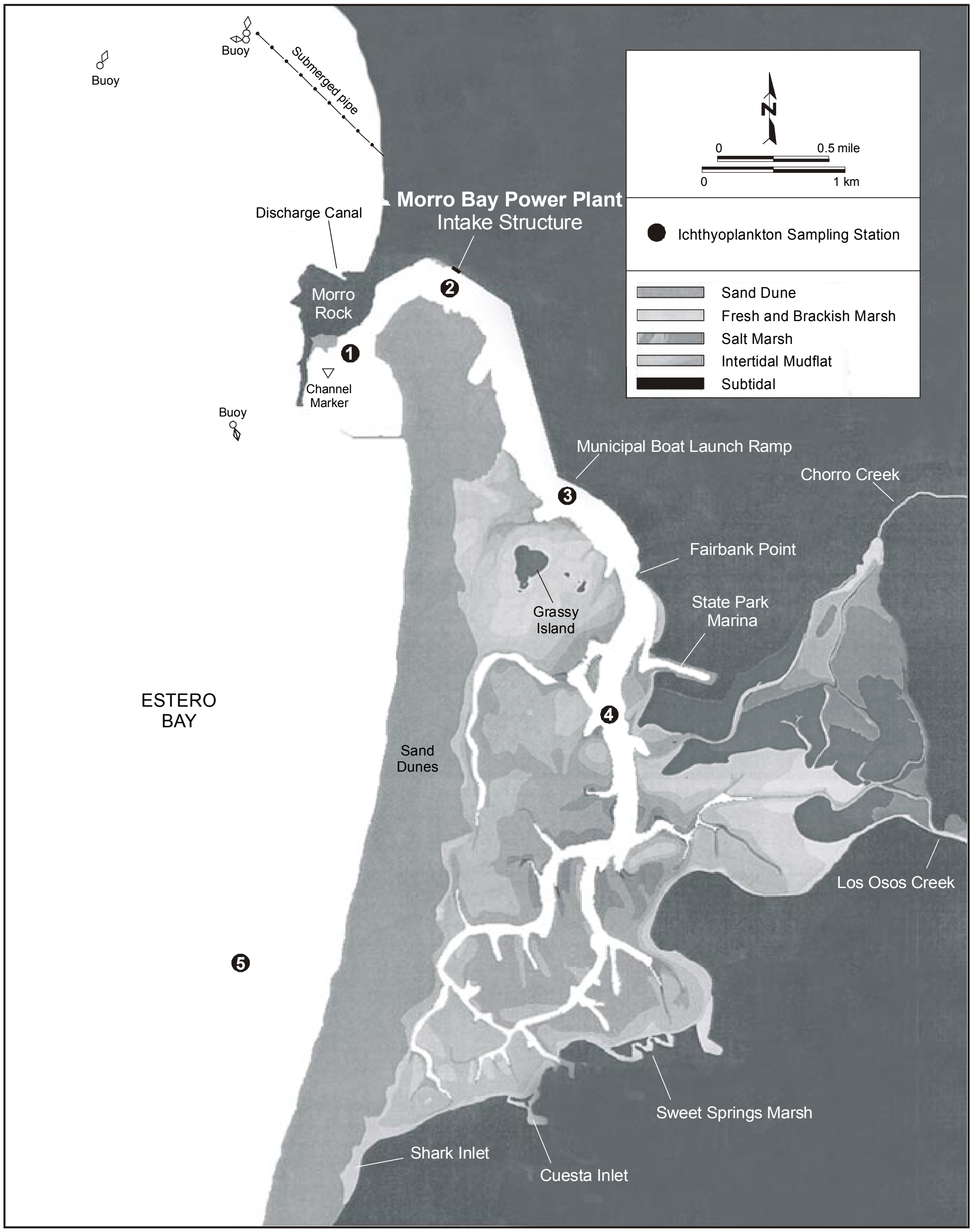

Figure 2-1. Morro Bay sampling stations.

We received a permit on December 2, 1999 and sampling resumed December 14, 1999 and will continue until on or about December 14, 2000. Table 2-1 summarizes the sampling frequency by station from June 1999 through the present.

2.2.2 Sampling Sufficiency

Species accumulation curves were calculated to assess the adequacy of a sampling effort (Krebs, 1989). A species accumulation curve depicts the number of new species (species not encountered before) collected during repeated sampling efforts. It is in effect a running tally of the number of species collected. The tally is cumulative so each species is counted only once. Generally, the slope of a species accumulation curve is steepest during early sampling efforts when new species are frequently encountered. As sampling continues fewer new species are collected so the slope of the curve tends toward zero. This trend may be confounded when computing a species accumulation curve over time, due to the reproductive cycles of species within the community. The species accumulation curves was computed from the mean, maximum, and minimum number of species sampled from 1,000 random iterations of the data to help account for seasonal differences in reproductive cycles among species. The accumulation of species during entrainment sampling from processed samples from June 1999 through May 2000 followed the expected patterns with rapid accumulation during the early sampling efforts that decreased with continued sampling (Figure 2-2).

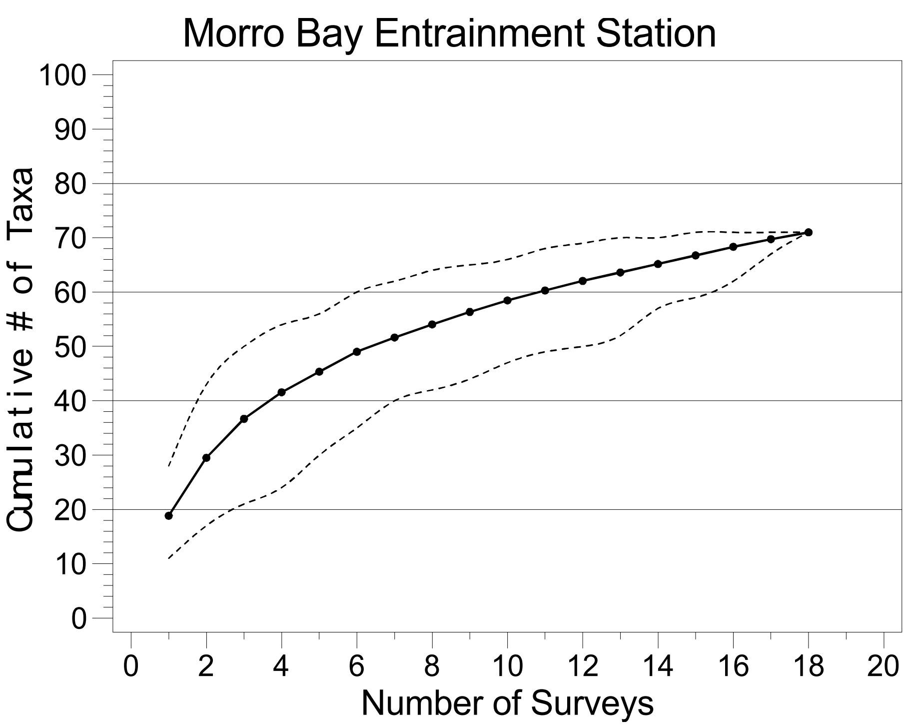

Figure 2-2. Mean (dotted line), maximum and minimum (dashed upper and lower lines) cumulative number of species from 1,000 iterations of data collected over 18 entrainment surveys.

2.3 Source Water Sampling

This study was designed to characterize the source water composition, abundance, and distribution of larval fishes and the megalopal stages of cancer and European green crabs. The data collected will aid in providing estimates of fractional loss as well as to help define boundaries of source populations.

Samples are collected at the following four source water stations (Stations 1, 3, 4, and 5; Figure 2-1; Station 2 is the entrainment station):

- Station 1 — In the entrance to Morro Bay.
- Station 2 — Intake (entrainment station, collected weekly).
- Station 3 — Off of the municipal boat launch ramp.
- Station 4 — Further south in the back bay.
- Station 5 — Located in Estero Bay approximately 2.5 nautical miles (2.9 statute miles) down coast of the entrance to Morro Bay.

Sampling of the source water stations consists of oblique tows using the same methods previously described in Section 2.1.1. All source water samples will be processed.

Table 2-1. Frequency of Collections for Morro Bay Power Plant Sampling Stations 1 through 5, June 1999 – Present.

Frequency of Collection	Dates	Number of Samples Collected per Survey						Total Samples per Station
Station 1		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999*	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–present	2	2	2	2	2	2	12
Station 2		1000	1400	1800	2200	0200	0600	
Weekly	Jun–Aug 9, 1999*	2	2	2	2	2	2	12
	Dec 14, 1999 – present	2	2	2	2	2	2	12
Station 3		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999*	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000 – present	2	2	2	2	2	2	12
Station 4		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999*	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–present	2	2	2	2	2	2	12
Station 5		Daytime High Tide			Daytime Low Tide			
Monthly	Jun–Jul 1999*	2			2			4
	Dec 1999–Jan 2000	2			2			4
	Time PST	0800	1200	1600	2000	2400	0400	
	Feb 2000–present	2	2	2	2	2	2	12

See Figure 2-1 for station locations.

* Sampling was suspended from August 9 through December 13, 1999 owing to the need for an incidental take permit for the protected tidewater goby.

2.3.1 Source Water Sampling Frequency

Monthly source water surveys began in June 1999. Following the July 1999 source water survey, sampling was suspended due to the need for an incidental take permit for the protected tidewater goby larvae found in the samples (see Section 2.2.1). Monthly source water sampling was reinstated in December 2000. Source water surveys were initially collected twice per day (Surveys 1-4; June, July, and December 1999 and January 2000); samples were collected during daylight high and low tides. In February 2000, sample collection for source water surveys was increased to cover a 24-hour period. The 24-hour sampling period is divided into six 4-hour cycles. Two samples are collected per cycle at each of the source water stations.

2.4 Laboratory Processing and Data Handling

Laboratory processing removes all larval fishes and the megalopal stages of *Cancer* spp. and European green crabs (*Carcinus maenas*) from the samples. Larval fishes and all cancer and European green crab megalops are identified to the lowest taxonomic level possible by TENERA's in-house taxonomists. In addition, the lifestage of fish larvae are identified on the data sheet. A laboratory quality control (QC) program for all levels of laboratory sorting and taxonomic identification is applied to all samples. The QC program also incorporates the use of outside taxonomic experts and DNA analysis to provide taxonomic QC and resolve taxonomic uncertainties.

Laboratory data sheets are coded with species or taxon codes. These codes are verified with species/taxon lists and signed off by the data manager. The data are entered into a computer database for analysis.

3.0 IMPINGEMENT STUDY

3.1 Study Purpose

Fishes and selected macroinvertebrates impinged at the MBPP intakes are currently sampled to assess the potential population-level impacts of impingement effects associated with the existing intake structures, flow rates, and volumes resulting from the modernization project. The assessment will specifically address the following questions:

- What are the species composition and abundance of juvenile and adult fishes and macroinvertebrates impinged by the MBPP?
- What are the abundance and distribution of source water species of impingeable fishes and selected macroinvertebrates in Morro Bay?
- What are the potential impacts of the power plant's cooling water system on juvenile and adult fishes and selected macroinvertebrates?

Field data on the composition and abundance of impinged fishes and selected macroinvertebrates will provide an estimate of the total number and types of these organisms impinged on the traveling screens of the MBPP. These data, assuming 100 percent impingement mortality, will be used to estimate impingement losses.

3.1.1 Current Cooling Water System Design Features

Two separate shoreline intake structures, one for Units 1 and 2 and one for Units 3 and 4, withdraw cooling water from the northern shore of Morro Bay. The shoreline intake structures for MBPP house the bar racks, vertical traveling screens, and chlorinators. Circulating water pumps serving the individual units are located about 30 ft (10 m) behind the screen structure. Each unit is equipped with two circulating water pumps, which discharge into separate pressure conduits, each supplying one half of a unit's steam condenser. Seawater entering the intake structure first passes through the bar racks that are designed to prevent the entry of large objects into the cooling water system. These bar racks are spaced 4 in. (10.2 cm) on center and are located about 20 ft (6 m) in front of the vertical traveling screens.

From the bar racks, water flows into the pump forebays, where the vertical traveling screens are housed. The screens, fabricated with 3/8-in. (0.95 cm) mesh, retain objects small enough to pass through the bar racks but larger than 3/8 inch. There are four vertical traveling screens for Units 1 and 2 and six traveling screens for Units 3 and 4. Each of the traveling screens is approximately 10 ft wide and extends from the upper decking of the intake structure to its bottom. Debris, fishes, and invertebrates retained by the traveling screens are removed during periodic screen rotation and washing. Screen washes can be initiated by timed cycles (typically every four hours, rinsing for a total of 15 min.), by manual operation (typically a continuous wash which may be necessary during periods of heavy algae and surfgrass accumulation), or by automatic activation initiated when a water level differential exceeds a predetermined maximum.

During screen washing, high-pressure nozzles (90–95 psi) wash debris and impinged organisms from the traveling screens. This material is washed from the traveling screens into sloping sluiceways that empty into two refuse sumps (one per unit group). Impinged material from all the units is returned to Estero Bay by a large-diameter pump that empties into the discharge conduit of Units 1 and 2. During impingement collections periods, the material rinsed into the sluiceways is carried by water flow into ¼-in. (0.64 cm) mesh-lined collection baskets located above the refuse sump pumps.

3.1.2 Impingement Study Methods

Impingement sampling occurs over a 24-hour period one day per week. Each sampling period is divided into six 4-hour cycles. Before each weekly sampling effort, all of the screens are rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets are cleaned before the start of each sampling effort. The operating status of the circulating water pumps is recorded every eight hours during the collection. The Units 1 and 2 traveling screens typically remain stationary for a period of 3 hours and 40 minutes, then they are rotated and rinsed for 20 minutes. The Units 3 and 4 traveling screens typically remain stationary for a period of 3 hours and 45 minutes, then they are rotated and rinsed for 15 minutes. The impinged material flows into one of two collection baskets. The debris and organisms rinsed from the Units 1 and 2 traveling screens is kept separate from the material from the Units 3 and 4 traveling screens.

All fishes and selected macroinvertebrates collected at the end of each 4-hour cycle are identified and counted. Table 3-1 shows the various taxonomic categories that are collected and the laboratory processing criteria that apply to the organism groups. Standard length (Osteichthys) and total length (Chrondrichthys) and the weight of all impinged fishes were recorded. Any mutilated or fragments of fishes that are collected are identified, if possible, but their lengths and weights are not recorded. Carapace width, mantle length, and test diameter are measured for crabs, cephalopod mollusks, and sea urchins, respectively. The amount of impinged debris is recorded. All data are recorded on data sheets, verified, and subsequently entered into a computer database.

A quality control (QC) program is implemented to ensure the correct identification, enumeration, length and weight measurements of the organisms recorded on the data sheet. Impingement cycles are randomly chosen for onsite QC re-sort to verify that all the organisms were removed from the impinged material.

Occasionally, there is such a large amount of debris collected on the traveling screens that the screens are continuously rotated and rinsed. Sample collection is suspended during those times because it is not safe to install and remove the collection baskets.

A log containing hourly observations of the operating status (on or off) of the circulating water pumps for the entire study period is obtained from the power plant. The data from these logs are is used to estimate the amount of cooling water withdrawn by the plant to compute impingement rates.

Table 3-1. Morro Bay Power Plant Impingement Study Sample Processing Criteria

Abundance Noted as Total Present/ Count Absent	Length	Weight	Condition of Specimen	Sex	Organism Type/Comments
X	X	X	X	X	Chrondrichthys (sharks, skates, rays) Total length measured.
X	X	X	X	X	Osteichthys (bony fishes) Standard length measured.
X	X	X	X	X	Decapod crabs Carapace width measured.
X	X	-	X	X	Cephalopod molluscs (octopus and squid) Mantle length measured.
X	X	-	X	-	Sea urchins Test diameter measured.

Note: - Length measurements will be made to the nearest 1.0 mm.
- Weight measurements will be made to the nearest 0.1 gram.
- Condition will be reported as alive, dead, mutilated, or fragmented.

3.1.2 Methods For Estimating Impingement Impacts

Impingement source water impacts can be evaluated using various estimates of source water populations: 1) CDFG catch block data, 2) CDFG party boat statistics, and 3) CDFG bimonthly otter trawl data for bottom dwelling fishes. Impingement rates and biomass estimates will be calculated from actual numbers of organisms impinged and compared to estimates of source water abundance and biomass. Data from the 24-hour collections each week are multiplied by seven to estimate the total number of organisms impinged in a week. The same method is used to calculate the weekly and annual biomass. Plant circulating water pump operating records supply the data for the volume of water pumped each week used to estimate weekly impingement rates.

4.0 INTRODUCTION TO SAMPLING PLAN AND MODELING EVALUATION

The purpose of this section is to describe three biological resource assessment methods that will be used to determine the effects of entrainment caused by the Morro Bay Power Plant (MBPP) intake system. Models and approaches, such as those described in this study plan, have been employed to estimate intake effects and to assess impacts at other power plants (e.g., Horst, 1975; Boreman et al., 1978, 1981; Goodyear, 1978; Parker and DeMartini, 1989; Summers, 1989; Cowan et al., 1993; VanWinkle et al., 1993; Saila et al., 1997). As advised in the USEPA (1977) draft document entitled *Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment: Section 316(b) Public Law 92-500*,

> "…The overall goal of conducting intake studies [316(b) demonstration studies] should be to obtain sufficient information on environmental impact to aid in determining whether the technology selected by the company is the best available to minimize adverse environmental impact. In the case of existing plants, this goal will be accomplished by providing reliable quantitative estimates of the damage that is or may be occurring and projecting the long-range effect of such damage to the extent reasonably possible."

Information from one or more of the approaches evaluated in this report will, in conjunction with other sources of resource management and ecological information, provide an assessment of adverse environmental impact.

4.1 Technical Work Group

The Central Coast Regional Water Quality Control Board (RWQCB) assembled a team of experts to assist the Board's staff in their review of the design and implementation of the 316(b) intake studies at MBPP. This team, the Technical Work Group (TWG), meets periodically to discuss topics relevant to ongoing efforts at MBPP including assessing entrainment and impingement effects. All of the data collected from sampling activities in these studies will be included in the final report. Results of an earlier impingement study at MBPP (PG&E, 1982) combined with the results of the ongoing MBPP impingement sampling and results from the ongoing MBPP entrainment and source water sampling have been used to create a preliminary list of potential target taxa. While sample collection to estimate power plant effects cannot be focused on any particular taxon, the final assessment of MBPP impact will be conducted for taxa from these target groups. These final assessment taxa will be chosen by the TWG based on criteria including statistical properties of the data and the availability of required life-history information. Generally, the most abundant and studied taxa form the basis of impact evaluation.

4.2 Modeling Approaches

Considerable effort among regulatory agencies and the scientific community has been expended on the evaluation of power plant intake effects over the past three decades. These efforts have helped to establish the context for the modeling approaches proposed to estimate entrainment and impingement effects at MBPP. The variety of approaches developed reflects the many differences in power plant locations and resource settings. MacCall et al. (1983), in their review of the various approaches, divided them into those that offer a judgment on the presence or absence of impact and those that describe the sensitivity of populations to varying operational conditions.

Impact assessment approaches considered in this evaluation include:

- estimated total annual entrainment described by John Skalski, University of Washington (Appendix A),
- proportional entrainment (*PE*), which is similar to that described by MacCall et al. (1983), used by Parker and DeMartini (1989), and described by Dave Mayer, Tenera Environmental and John Skalski, University of Washington (Appendix C),
- adult-equivalent loss (*AEL*) (Horst, 1975; Goodyear, 1978), and
- fecundity hindcasting (*FH*) proposed by Alec MacCall, NOAA/NMFS, which also is related to the adult-equivalent loss approach.

These approaches can be placed under the umbrella of two general models: the empirical transport model (*ETM*; Boreman et al., 1978) (*PE* as an input); and the equivalent adult model (*EAM*; Horst, 1975; Goodyear, 1978) including adult equivalent loss (*AEL*) and fecundity-hindcasting (i.e., the demographic approaches). The *PE* can also be interpreted as “conditional fishing mortality” as defined by Ricker (1975).

Early forms of adult/recruitment relationships have evolved to more complex present-day forms of individual-based modeling. For example, large-scale research efforts have been expended on striped bass, *Morone saxatilis* (Cowan et al., 1993; Van Winkle et al., 1993). The resulting models are species- and site-specific, incorporating precise descriptions of life histories, growth, survivorship, as well as ecological, water quality, and trophic conditions. Such detailed information is not available for species potentially impacted by MBPP. Therefore, a more empirically based modeling approach is proposed for this 316(b) study.

The first step in estimating the effects of entrainment losses in the MBPP intake structure is to estimate the concentrations of organisms being entrained. The methods for achieving these estimates have been described in detail in Section 2.0. Briefly, entrainment concentrations are estimated from bongo-net plankton samples collected at a station positioned directly in front of the MBPP intake structure. These concentration estimates represent the "damage that is or may be occurring" (USEPA, 1977) as the result of MBPP's cooling water intake. The second step in this process is to place these data in a context that allows "projecting the long range effects" (i.e., the impact assessment; USEPA, 1977).

Several methods for estimating impacts, including *ETM*, will be applied to MBPP intake effects. The application of several models to estimate power plant effects is not unique (Murdoch et al., 1989; PSE&G, 1993). Adult-equivalent loss is an accepted method that has been applied in other 316(b) demonstrations (PSE&G, 1993) and will be applied at MBPP as well; the *FH* presented in this document is analogous to *AEL*. The advantage of these latter two approaches is that they translate larval losses into adult fishes that are familiar units to fishery managers.

Population boundaries of the species affected by MBPP cooling water intake vary with each species' life history according to location and residence time of the species' various life stages. These boundaries will be defined by working assumptions determined through discussions with the TWG, hydrodynamists, and other fishery and resource managers. Approximately 70 percent of the bay is exchanged tidally each day (Tetra Tech, 1999). While the *PE* method can be expanded upon, it may be employed to avoid the potential difficulty of estimating population or stock boundaries by estimating a relative loss of individuals from an agreed upon source water area (e.g., the study area proposed for the *PE* sampling below). Estimating *PE* also presents the advantage of comparing larval losses directly to larval supplies without the need for life stage mortality estimates to convert larval losses to equivalent adults. The *PE* fractional loss of larvae yields a direct estimate of conditional entrainment mortality on the entrained taxa.

An important issue that will arise when "estimating long range effects" is density-dependence (sometimes called compensation) of the vital rates of impacted organisms. Density-dependence is not confined to acting through mortality; growth and fecundity may also be density-dependent. Some entrainment studies have assumed that compensation is not acting between entrainment and the time when adult recruitment would have taken place, and further, that this specific assumption resulted in conservative estimates of projected adult losses (Saila et al., 1997). Others, such as Parker and DeMartini (1989), did not include compensatory mortality in estimates of equivalent adult losses, because of a lack of consensus on how to include it in the models and, more importantly, uncertainty about how compensation would operate on the populations under study. The uncertainty arises from a lack of understanding about the effect of compensation on which vital processes (fecundity, somatic growth, mortality) and which life stages are being affected. In particular, Nisbet et al. (1996) showed that neglecting compensation does not always lead to conservative long-term estimates of equivalent adult losses. Due to the uncertainty of achieving consensus on evaluation of compensation, the presently planned approach to impact assessment will not incorporate a compensation factor. However, not withstanding the special cases described by Nisbet et al. (1996), we believe that not including a compensation factor generally produces a conservative estimate of adult equivalent losses.

5.0 ESTIMATING MBPP ENTRAINMENT EFFECTS

Larval sampling at the cooling water intake will provide periodic estimates of daily as well as annual larval entrainment at the MBPP. Estimates of entrainment loss, in conjunction with demographic data collected from the fisheries literature, will permit modeling of adult equivalent loss (*AEL*) and fecundity hindcasting (*FH*). Additional sampling at the potential source populations of larvae in Morro Bay and Estero Bay provides the information needed to estimate the probability of annual fractional losses of entrained larvae using the Empirical Transport Model (*ETM*). Considering the guidelines established in the EPA draft document (EPA, 1977) and given the constraints of the data and available demographic information for the larvae entrained, the TWG will determine which taxa within these groups will be included in more detailed analyses of entrainment effects when sufficient data have been collected. The data requirements, assumptions, outputs, advantages, and disadvantages of these approaches are summarized in Tables 5-1 and 5-2. In the MBPP 316(b) study, we will use each approach (i.e., *AEL*, *FH*, and *ETM*) as appropriate for each taxon to assess effects of entrainment losses.

5.1. Demographic Approaches

Adult equivalent loss models evolved from impact assessments that compared power plant losses to commercial fisheries harvests and/or estimates of the abundance of adults. In the case of adult fishes impinged by intake screens, the comparison was relatively straightforward. To compare the numbers of impinged sub-adults and juveniles and entrained larval fishes to adults, it was necessary to convert all these losses to adult equivalents. Horst (1975) provided an early example of the equivalent adult model (*EAM*) to convert numbers of entrained early life stages of fishes to their hypothetical adult equivalency. Goodyear (1978) extended the method to include the extrapolation of impinged juvenile losses to equivalent adults.

Demographic approaches, exemplified by the *EAM*, produce an absolute measure of loss beginning with simple numerical inventories of entrained or impinged individuals and increasing in complexity when the inventory results are extrapolated to estimate numbers of adult fishes or biomass. We will use two different but related demographic approaches in assessing entrainment effects at MBPP: *AEL*, which expresses effects as absolute losses of numbers of adults, and *FH*, which estimates the number of adult females whose reproductive output has been eliminated by entrainment of larvae.

Table 5-1. Data Requirements and Outputs for Three Approaches Proposed to Estimate Effects of Cooling Water Withdrawals at MBPP.

Approach	Data Required	Assumptions	Output
Proportional Entrainment (*PE*)	• Taxon-specific estimates of entrainment losses. • Comparable life stage estimates of taxon's abundance (concentration) in source water.	• Source water samples are representative of the composition and abundance of larvae in the study area. • Entrainment samples are representative of the organisms entrained in the cooling water.	• Estimated fraction of larval concentration removed from the source water by entrainment.
Adult Equivalent Loss (*AEL*)	• Taxon-specific estimates of entrainment and impingement losses. • Age-specific mortality schedules for selected taxa from entrainment-impingement to some predetermined life stage (e.g., recruitment). • Fishery resource abundance estimates for relative impact assessments.	• Age-specific mortality rates are constant for the population. • Population at long-term equilibrium for relative impact assessments (not required for calculations). • Entrainment samples are representative of the organisms entrained in the cooling water.	• Number of animals that would have survived to adulthood had they not been entrained or impinged by the intake.
Fecundity Hindcast (*FH*)	• Taxon-specific estimates of entrainment and impingement losses. • Species- and age-specific adult fecundity. • Age-specific mortality schedules for selected taxa from parturition/hatch to entrainment/ impingement.	• Age-specific mortality rates are constant for the population. • Population at long-term equilibrium for relative impact assessments (not required for calculations). • Entrainment samples are representative of the organisms entrained in the cooling water.	• Number of sexually mature females represented by the losses of reproductive output due to entrainment and/or impingement.

Table 5-2. Advantages and Disadvantages of the Three Approaches Proposed to Estimate Effects in the MBPP 316(b) Assessment.

Approach	Advantages	Disadvantages
Proportional Entrainment (*PE*)	• Empirical estimate of *PE* compares larvae entrained to larvae in the source water. • Age- and species-specific survivorship data not required. • Can be converted to proportional habitat losses.	• Scaling intake effects up to population level impacts, but may be problematic. • Estero Bay taxa (e.g., *Genyonemus lineatus*). Open ocean not adequately sampled in present design.
Adult Equivalent Loss (*AEL*)	• Entrainment/impingement losses are expressed as adults facilitating the interpretation of population-level impacts. • Common usage in 316(b) studies.	• Difficult to interpret for entrained organisms in broad taxonomic categories (e.g., Gobiidae) containing multiple life-histories. • Age- and species-specific mortality data are little known or unavailable for many organisms that are entrained/impinged by the intakes. • Local adult population sizes not well described by fishery catch data for mixed species (e.g., *Sebastes* spp., Pleuronectidae, etc).
Fecundity Hindcast (*FH*)	• Entrainment/impingement losses are expressed as adults facilitating the interpretation of population-level impacts.	• Age- and species-specific mortality data are little known or unavailable for many organisms that are entrained/impinged by the intakes. • Local adult population sizes not well described by fishery catch data for mixed species (e.g., *Sebastes* spp, Pleuronectidae, etc). • Scaling intake effects up to population level impacts may be problematic. • Age- and species-specific fecundity data have not been previously reported for many organisms that are entrained/impinged by intakes.

Age-specific survival and fecundity rates are required for *AEL* and *FH*. Adult-equivalent loss estimates require survivorship estimates from the age at entrainment to adult recruitment; *FH* requires egg and larval survivorship until entrainment. Furthermore, to make estimation practical, the affected population is assumed to be stable and stationary, and age-specific survival and fecundity rates are assumed to be constant over time. Each of these approaches provides estimates of adult fish loss which may still need to be placed into context regarding standing fish stocks.

Species-specific survivorship information (e.g., age-specific mortality) from egg or larvae to adulthood is limited for many of the taxa likely to be considered in this assessment. Thus, in many cases, these rates must be inferred from the literature along with their measures of uncertainty. Uncertainty surrounding published demographic parameters is seldom known and rarely reported, but the likelihood that it is very large should be considered when interpreting results from the demographic approaches for estimating entrainment effects. For some well-studied species (e.g., the northern anchovy, *Engraulis mordax*), portions of their early mortality schedules and fecundity have been reported (e.g., Parker, 1980; Zweifel and Smith, 1981; Hewitt, 1982; Hewitt and Methot, 1982; Hewitt and Brewer, 1983; Lo 1983, 1985, 1986; McGurk, 1986). Because the accuracy of the estimated entrainment effects from *AEL* and *FH* will depend on the accuracy of age-specific mortality and fecundity estimates, lack of demographic information may limit the utility of these approaches.

The precursor to the *AEL* and *FH* calculations is an estimate of total annual larval entrainment. Estimates of larval entrainment at MBPP will be based on periodic tow samples with total annual entrainment expressed as

$$\hat{E}_T = \hat{E}_{1-2} \quad (1)$$

where $\hat{E}_T$ is the estimate of total entrainment and $\hat{E}_{1-2}$ is the weekly entrainment sampling (Appendix A). Estimates of total entrainment are based on two-stage sampling designs, with days within periods and replicate tows within days. The within-day sampling is based on a stratified random sampling scheme with four temporal strata corresponding to tidal flows (Appendix A). For periods when 24-hr source water sampling occurred, temporal strata may also correspond to day and night conditions.

***5.1.1 Adult Equivalent Loss* (AEL)**

The *AEL* approach uses estimates of the abundance of the entrained or impinged organisms (i.e., $\hat{E}_T$) to project the loss of equivalent numbers of adults based on mortality schedules and age-at-recruitment. The primary advantage of this approach is that it translates power plant-induced early life-stage mortality into numbers of adult fishes that are familiar units to resource managers. Adult equivalent loss does not require source water estimates of larval abundance in assessing effects. This latter advantage may be offset by the need to gather age-specific mortality rates to predict adult losses and the need for information on the adult population of interest for estimating population-level effects (i.e., fractional losses). However, the need for age-specific mortality estimates can be reduced by various forms of approximation as show by Saila et al. (1997). They describe an *AEL* and apply it to six years of entrainment and two years of impingement data for winter flounder *Pleuronectes americanus*, red hake *Urophycis chuss*, and pollock *Pollachius virens* at the Seabrook Station, in New Hampshire, and contrast these with equivalent adult losses of winter flounder at Pilgrim Station, another coastal power plant. Their model assumes an adult population at equilibrium, a stable age distribution, a constant male:female ratio, and an absence of density-dependent (i.e., compensatory) mortality between entrainment and recruitment to the adults.

Starting with the number of age class i larvae entrained $\left(\hat{E}_i\right)$, it is conceptually easy to convert these numbers to an equivalent number of adults lost $\left(A\hat{E}L\right)$ at some specified age class from the formula:

$$A\hat{E}L = \sum_{i=1}^{n} \hat{E}_i S_i \qquad (2)$$

where

n = number of age classes;

$\hat{E}_i$ = estimated number of larvae lost in age class i; and

S_i = survival probability for the *i*th class to adulthood (Goodyear, 1978).

Age-specific survival rates from larval stage to recruitment into the fishery must be included in this assessment method. For some commercial species, natural survival rates are known after the fish recruit into the commercial fishery. For the earlier years of development, this information is not well-known and may be lacking for noncommercial species.

The information on survival probabilities in Equation (2) will likely be unknown, in which case a simplified *AEL* expression can be written as

$$A\hat{E}L = \hat{E}_T \cdot \hat{S}_A \qquad (3)$$

where

$\hat{S}_A$ = survival from the average age of larval entrainment to adulthood.

The exact variance for Equation (2) can be expressed as

$$Var\left(A\hat{E}L\right) = E_T^2 \cdot Var\left(\hat{E}_T\right) + S_A^2 \cdot Var\left(\hat{S}_A\right) + Var\left(\hat{E}_T\right) \cdot Var\left(\hat{S}_A\right).$$

An alternative expression of adult-equivalent loss would be to standardize $A\hat{E}L$ by the size of the adult population of interest to estimate the relative magnitude of the equivalent adult loss such that,

$$RA\hat{E}L = \frac{A\hat{E}L}{\hat{P}}, \tag{4}$$

where $\hat{P}$ = estimated size of the adult population of interest. Information on the number of adults in the source population may be limited for many species and thereby limit the utility of Equation (4).

*5.1.2 Fecundity Hindcasting (*FH*)*

The *FH* approach compares larval entrainment losses with adult fecundity to estimate the amount of adult female reproductive output eliminated by entrainment and thereby hindcasts the numbers of adult females effectively removed from the reproductively active population. The accuracy of these estimates of effects, as with those of the *AEL* above, are dependent upon accurate estimates of age-specific mortality from the egg and early larval stages to entrainment. If it can be assumed that the adult population has been stable at some current level of exploitation and that the male:female ratio is constant and 50:50, then fecundity and mortality are integrated into an estimate of loss by converting entrained larvae back into females (i.e., hindcasting).

A potential advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (i.e., egg to larval entrainment). The method requires age-specific mortality rates and fecundities to estimate entrainment effects and some knowledge of the abundance of adults to assess the fractional losses these effects represent. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of an adult fish which may be inaccurate.

In the *FH* approach, the total of larval entrainment for a species $\left(\hat{E}_T\right)$ will be projected backward to estimate the number of breeding females required to provide the numbers of larvae seen in the entrainment samples. The estimated number of breeding females $\left(\hat{F}H\right)$ whose fecundity is equal to the total loss of entrained larvae would be calculated as follows:

$$\hat{F}H = \frac{1}{\hat{\bar{F}}_T} \sum_{j=1}^{w} \frac{\hat{E}_j}{S_j} \qquad (5)$$

where

w = number of weeks the larvae are vulnerable to entrainment;

$\hat{E}_j$ = estimated total entrainment for the jth week $(j = 1, \ldots, w)$;

S_j = survival rate from eggs to larvae of the stage present in the jth week $(j = 1, \ldots, w)$;

$\hat{\bar{F}}_T$ = average total lifetime fecundity for females, equivalent to the average number of eggs spawned per female over their reproductive years.

The two key input parameters in Equation (5) are fecundity $\hat{\bar{F}}_T$ and very early survival rates (S_j) from spawning to week j of the survey. Descriptions of these parameters may be limited for many species and are a possible limitation of the method. Typically, the information for the fine-grained age structure of the Equation (5) will not be available, and the *FH* calculations will be reduced to

$$\hat{F}H = \frac{\hat{E}_T}{\hat{\bar{F}}_T \hat{S}_L} \qquad (6)$$

where

S_L = survival from egg to the average age of larval entrainment.

The variance for the *FH* calculations [Equation (6)] is

$$Var(\hat{F}H) \doteq (FH)^2 \left[CV(\hat{E}_T)^2 + CV(\hat{\bar{F}}_T)^2 + CV(\hat{S}_L)^2 \right] \qquad (7)$$

where, in general,

$$CV(\hat{\theta})^2 = \frac{Var(\hat{\theta})}{\hat{\theta}^2}.$$

An alternative interpretation of *FH* is possible by expressing the estimate in terms of the relative size of the adult fish stock in the source populations where

$$R\hat{F}H = \frac{\hat{F}H}{\hat{P}_F} \quad (8)$$

where $\hat{P}_F$ = an estimate of the abundance of breeding adult females in the area of interest. Here, the fecundity hindcasting estimate $\left(R\hat{F}H\right)$ is the proportion of the breeding adults whose fecundity was lost due to entrainment by MBPP.

5.2 Empirical Transport Model (*ETM*)

The empirical transport model (*ETM*) has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals at power plants (Boreman et al., 1978, 1981). Variations of this model have been discussed in MacCall et al. (1983) and used to assess impacts (Parker and DeMartini, 1989). The *ETM* has been used to assess impacts at the Salem Nuclear Generating Station in Delaware Bay, New Jersey (PSE&G, 1993) as well as other power stations along the East Coast. The *ETM* approach was also used at Diablo Canyon Power Plant in California. We will employ a method similar to that described by MacCall et al. (1983) and used by Parker and DeMaritini (1989) while under contract to the Marine Review Committee in their final report to the California Coastal Commission (Murdoch et al., 1989) for San Onofre Nuclear Generating Station on the coast of southern California. Empirical transport modeling permits the estimation of annual conditional mortality due to entrainment while accounting for the spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The generalized form of *ETM* incorporates many time-, space-, and age-specific estimates of mortality as well as information regarding spawning periodicity and duration, most of which are limited or unknown for the marine taxa being investigated.

The purpose of the *ETM* calculations is to estimate the probability of mortality of larvae associated with power plant entrainment. The calculations require not only the abundance of larvae entrained but also the abundance of the larval populations at risk of entrainment. The sampling at the cooling water intakes is used to estimate entrained numbers. At MBPP we propose, based on the entrainment of both oceanic and bay species, to define the larval source population the larval source population as those larvae in Morro Bay and Estero Bay.

On any one sampling day, the conditional entrainment mortality can be expressed as

$$PM_{ij} = \frac{E_{ij}^{T}}{R_{ij}} \quad (9)$$

where

E_{ij}^{T} = total numbers of larvae entrained on the *j*th day $\left(j=1,\ldots,d_i\right)$ of the *i*th temporal sampling stratum $(i=1,\ldots,L)$;

R_{ij} = numbers of larvae at risk of entrainment, i.e., abundance of larvae in Morro Bay (MB), and Estero Bay (EB).

In turn, the abundance of entrained larvae can be expressed as the sum of the entrainment numbers at Units 1 and 2 where

$$E_{ij}^{T} = E_{ij}^{1-2} \tag{10}$$

and E_{ij}^{1-2} is the entrainment abundance at Units 1 and 2 on the *j*th sampling day. With the larval source populations *a priori* defined, the abundance of larvae at risk can then be directly expressed as

$$R_{ij} = V_{MB} \cdot \bar{D}_{MBij} + V_{EB} \cdot \bar{D}_{EBij} \tag{11}$$

where V denotes the water volume and $\bar{D}$, the average larval density in a source population during the *ij*th sampling day. The volume of Morro Bay (V_{MB}) is the combined static and daily tidal prism volumes. Both the volume of Morro Bay and its tidal prism will be based on volumes using mean high (MHW) and low tide (MLW) datum and the most current bathymetric information in available literature as might be confirmed by additional field observations. The volume of Morro Bay (V_{MB}) will be used heuristically as a first order approximation of the minimum source water volume of Estero Bay (V_{EB}) larvae at risk to MBPP entrainment. The volume of Morro Bay (5,375,394,600 gallons) is calculated as the total daily tidal exchange volume (tidal prism) plus non-tidal volume. A detailed description of the calculation of this volume can be found in MBPP Project AFC Section 6.5. Using the modernized facility's design intake rate of 330,000 gpm (491,832,000 gallons/tidal day), the daily power plant CWS withdrawal is 9.1 percent of the Morro Bay daily tidal and static volume. The effects of the winter freshwater outflow are not included in the estimated Morro Bay volume, but would increase the effective daily volume and reduce the fraction withdrawn by the new facility. The approximation makes the conservative assumption that there is no larger volume of larval supply of species found in Estero Bay than could be contained in the smaller volume of Morro Bay. The approximation however provides a fair estimate source larval supply for Morro Bay species collected in Estero Bay.

Combining Equations (9–11), the probability of entrainment for a larvae in the four tidal or six temporal source populations during the *ij*th sampling day can be estimated (Appendix C) by

$$\hat{P}M_{ij} = \frac{\left(\hat{E}_{ij}^{T}\right)}{\left(V_{MB} \cdot \hat{\hat{D}}_{MBij} + V_{EB} \cdot \hat{\hat{D}}_{EBij}\right)}. \tag{12}$$

The *ETM* model uses the periodic estimates of $\hat{P}M_{ij}$ to estimate the annual probability of entrainment mortality.

How the *ETM* calculations incorporate the individual estimates of $\hat{P}M_{ij}$ depends on the nature of the entrainment process and on the nature of the spawning and hatching sequence of the fish and cancer crab species. Model formulation will differ whether there is a single synchronous breeding or whether there is multiple overlapping breeding by the fish or cancer crab species. In the case of a single synchronous breeding, the *ETM* can be formulated as

$$\hat{P}M = 1 - \prod_{i=1}^{L}\prod_{j=1}^{d_i}\left(1 - \hat{P}M_{ij}\right)^{D'_{ij}} \tag{13}$$

where D'_{ij} = number of days represented by the *ij*th sampling period. In Equation (13), the estimated entrainment mortality probability $\hat{P}M_{ij}$ is assumed to be representative of the daily mortality during the D_{ij} period of time.

In the case where there are multiple non-overlapping spawnings, the *ETM* calculations can be formulated as

$$\hat{P}M = 1 - \sum_{i=1}^{L}\sum_{j=1}^{d_i} f_{ij}\left(1 - P_{M_{ij}}\right)^{D'_{ij}} \tag{14}$$

where f_{ij} = fraction of the spawning that occurred during the *ij*th sampling period. Equation (14) assumes the population-wide probability of entrainment is the essence of the *ETM* approach of MacCall et al. (1983). If this population is stable and stationary, then $P\hat{P}E$ is also an indicator of the effects on the fully recruited age classes when no compensatory natural mortality is assumed.

6.0 PRELIMINARY FINDINGS

6.1 Entrainment and Source Water

Unidentified gobies, unidentified blennies, Pacific staghorn sculpin, northern lampfish, blackeye goby, and jacksmelt comprised nearly 90 percent of the fishes collected during weekly entrainment surveys.[1] The percent composition of these species is shown in Figure 6-1. Unidentified gobies also accounted for a majority (90.4 percent) of the number of larval fishes collected at the Morro Bay source water stations (Stations 1, 3, and 4).[2] The percent composition of the most abundant fishes collected from the Morro Bay source water stations is shown in Figure 6-2. Unidentified gobies and northern lampfish comprised 67 percent of the total number fishes collected at the Estero Bay source water station (Station 5).[3] The percent composition of the species collected from the Estero Bay source water station is shown in Figure 6-3. A summary of the mean survey concentrations of the larval fish taxa identified from entrainment and source water surveys can be found in the MBPP 316(b) Fourth Quarterly Report dated July 31, 2000 (Tenera Environmental, 2000).

6.2 Impingement

Eleven species comprised nearly 90 percent of the fishes impinged at Units 1 and 2 from September 9, 1999 through July 6, 2000. Northern anchovy, plainfin midshipman, speckled sanddab, English sole, Pacific staghorn sculpin, and topsmelt accounted for nearly 79 percent of the total. Ten species comprised approximately 85 percent of the fishes impinged at Units 3 and 4. Topsmelt, plainfin midshipman, northern anchovy, and speckled sanddab accounted for 68 percent of the total. The percent composition of fishes for Units 1 and 2 and Units 3 and 4 is shown in Figures 6-4a and 6-4b, respectively. Results of the impingement surveys conducted from inception through July 6, 2000 are presented in the MBPP 316(b) Fourth Quarterly Report dated July 31, 2000 (Tenera Environmental, 2000).

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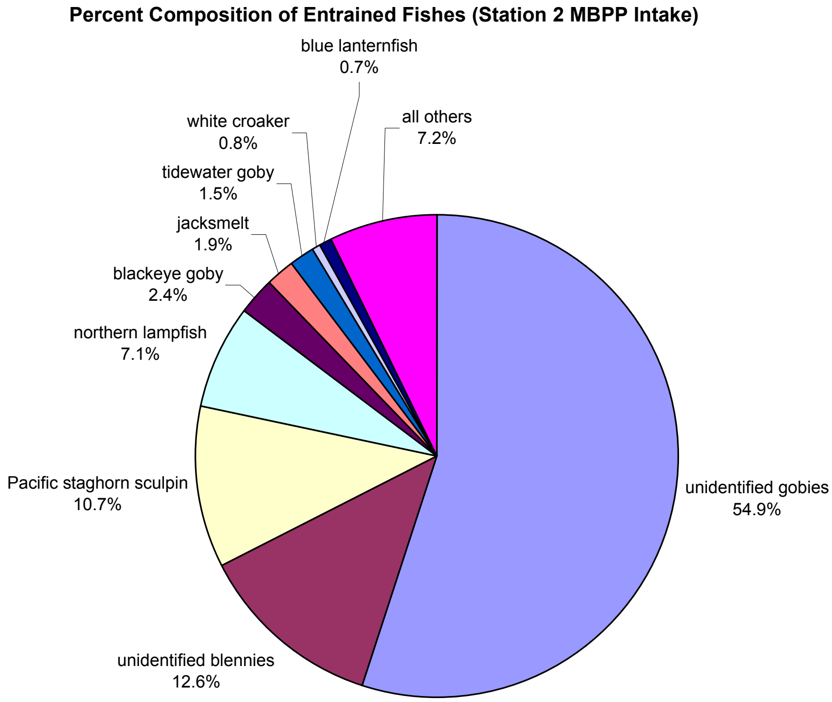
[1] These preliminary results are based on weekly samples that were collected on the following dates: June 21 through August 9, 1999; December 14, 1999 through January 17, 2000; February 28, 2000; and March 27, 2000. See Section 2 for an explanation of sample collection dates.

[2] These preliminary results were based on monthly samples that were collected on the following dates: June and July 1999; and December 1999 through February 2000.

[3] These preliminary results were based on monthly samples that were collected on the following dates: June and July 1999; and December 1999 through February 2000.

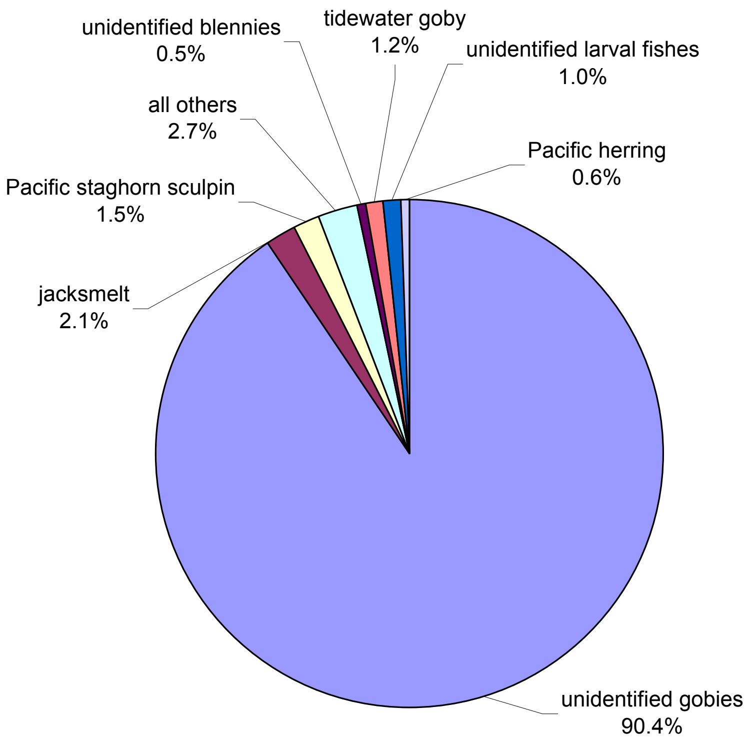


Data are preliminary because quality control checks are not complete.

Figure 6-1. Percent composition of entrained larval fishes at Morro Bay Power Plant (Station 2—MBPP Intake) Surveys 1 through 14, 20, and 24.

Note: Total does not add to 100 percent because of rounding.

Percent Composition of Fishes at Morro Bay (Stations 1, 3 and 4)



Data are preliminary because quality control checks are not complete.

Figure 6-2. Percent composition of larval fishes collected at source water stations 1, 3, and 4 (Surveys 1 through 5).

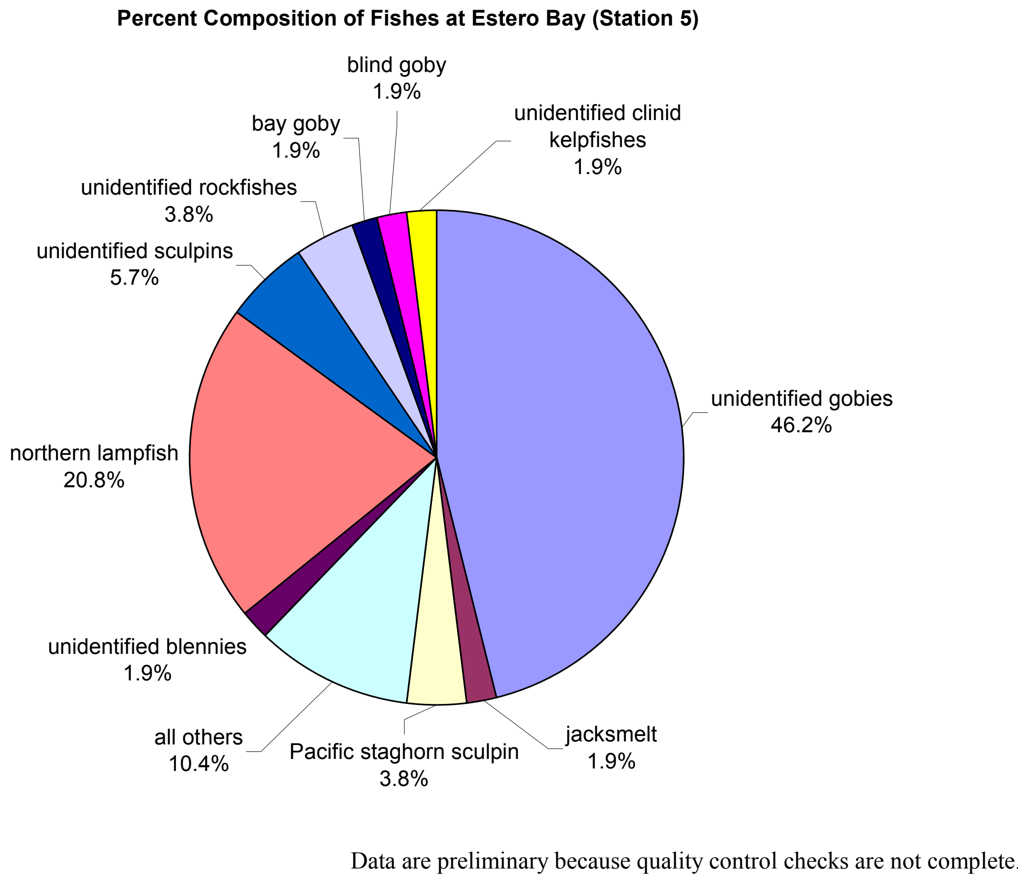


Figure 6-3. Percent composition of larval fishes collected at source water Station 5 (Surveys 1 through 5).

Nine species and unidentified cancer crabs impinged at Units 1 and 2 (from the macroinvertebrate group of concern) comprised nearly 90 percent of the group total. This group of macroinvertebrates included four crab species (*Portunus xantusii*, *Cancer jordani*, *Cancer antennarius*, and *Pugettia producta)* and unidentified cancer crabs, three shrimp species (*Crangon nigricauda*, *Crangon nigromaculata*, and *Penaeus californiensis*), *Strongylocentrotus purpuratus* (purple sea urchins), and *Loligo opalescens* (squid). Twelve species and unidentified cancer crabs (from the macroinvertebrate group of concern) impinged at Units 3 and 4 comprised nearly 90 percent of the group total. Included in this group were seven crab species (*Portunus xantusii*, *Cancer jordani*, *Cancer antennarius, Pugettia richii, Pugettia producta, Loxorhynchus crispatus,* and *Pachygrapsus crassipes*) and unidentified cancer crabs, three shrimp species (*Crangon nigricauda*, *Crangon nigromaculata*, and *Penaeus californiensis*), *Strongylocentrotus purpuratus* (purple sea urchins), and *Loligo opalescens* (squid). The percent composition of invertebrates for Units 1 and 2 and Units 3 and 4 is shown in Figures 6-5a and 6-5b, respectively.

(a)

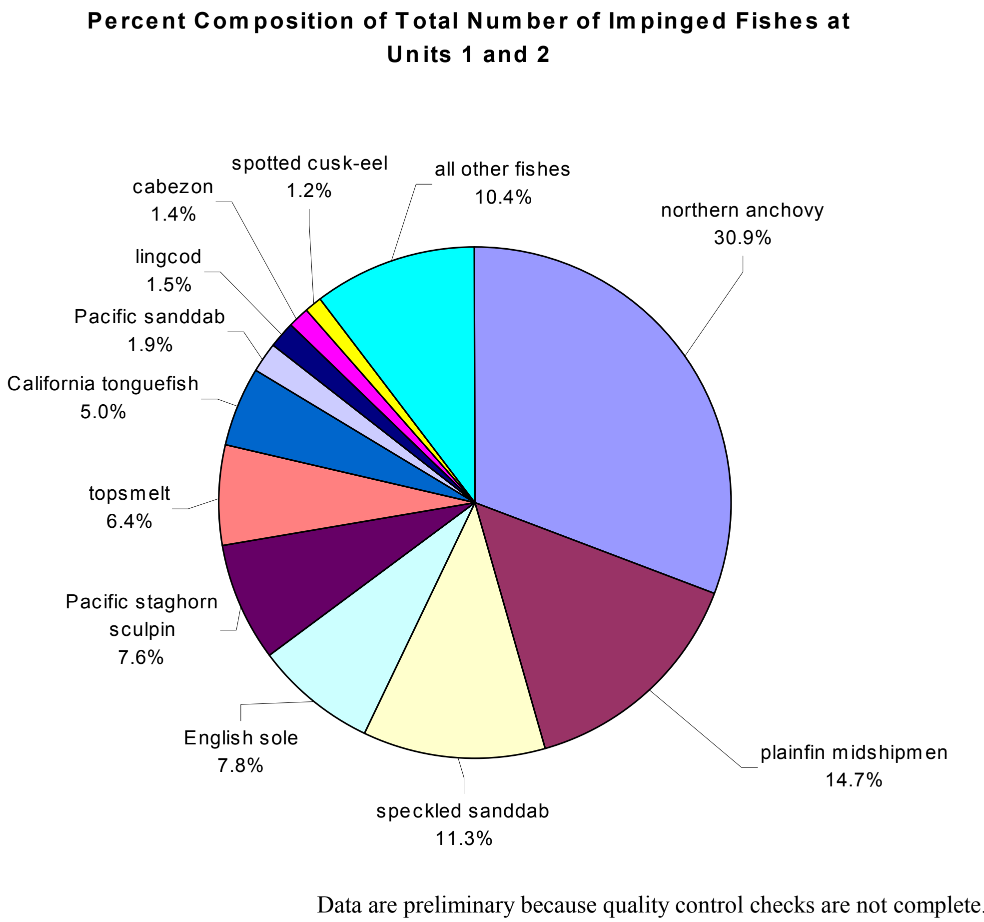


Figure 6-4a. Percent composition of impinged fishes at Morro Bay Power Plant Units 1 and 2 (September 9, 1999 through July 7, 2000).

(b)

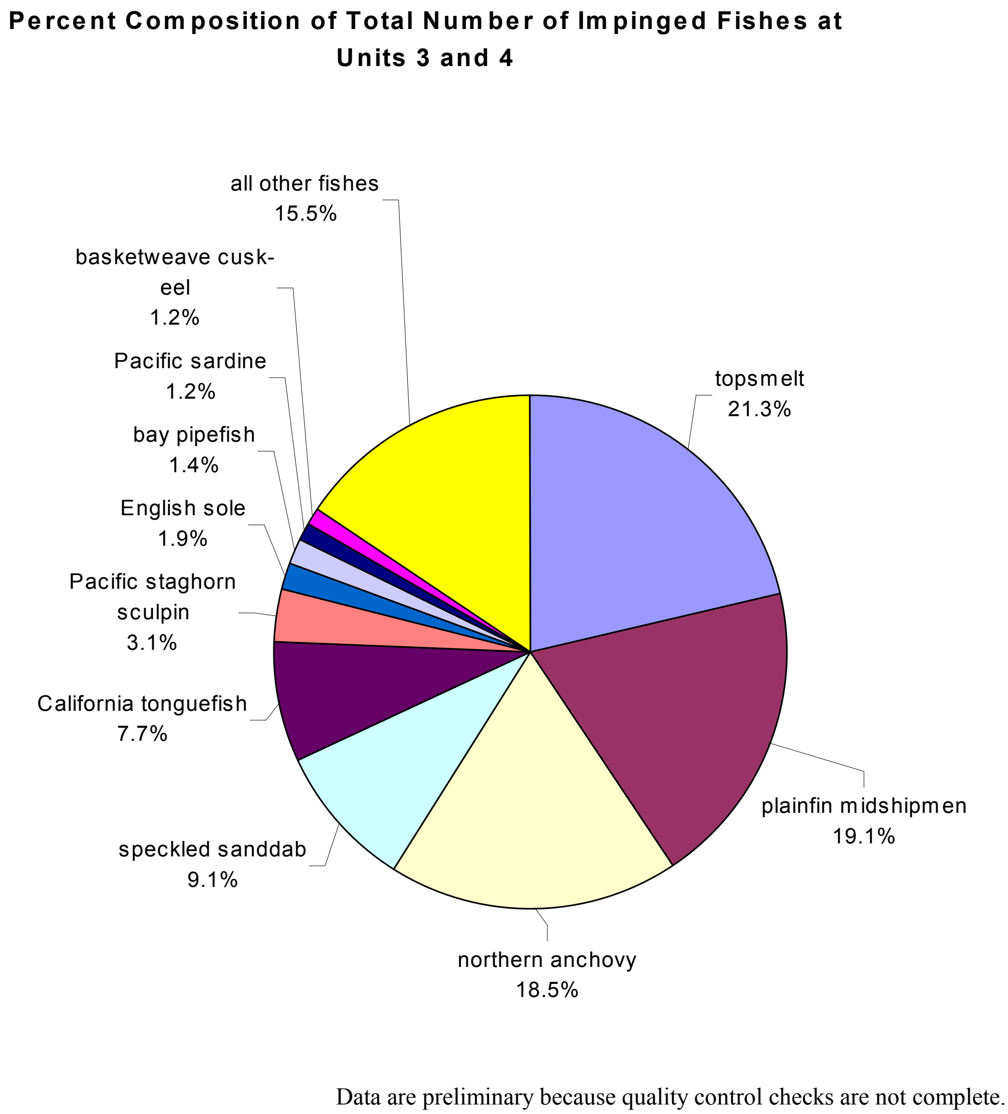
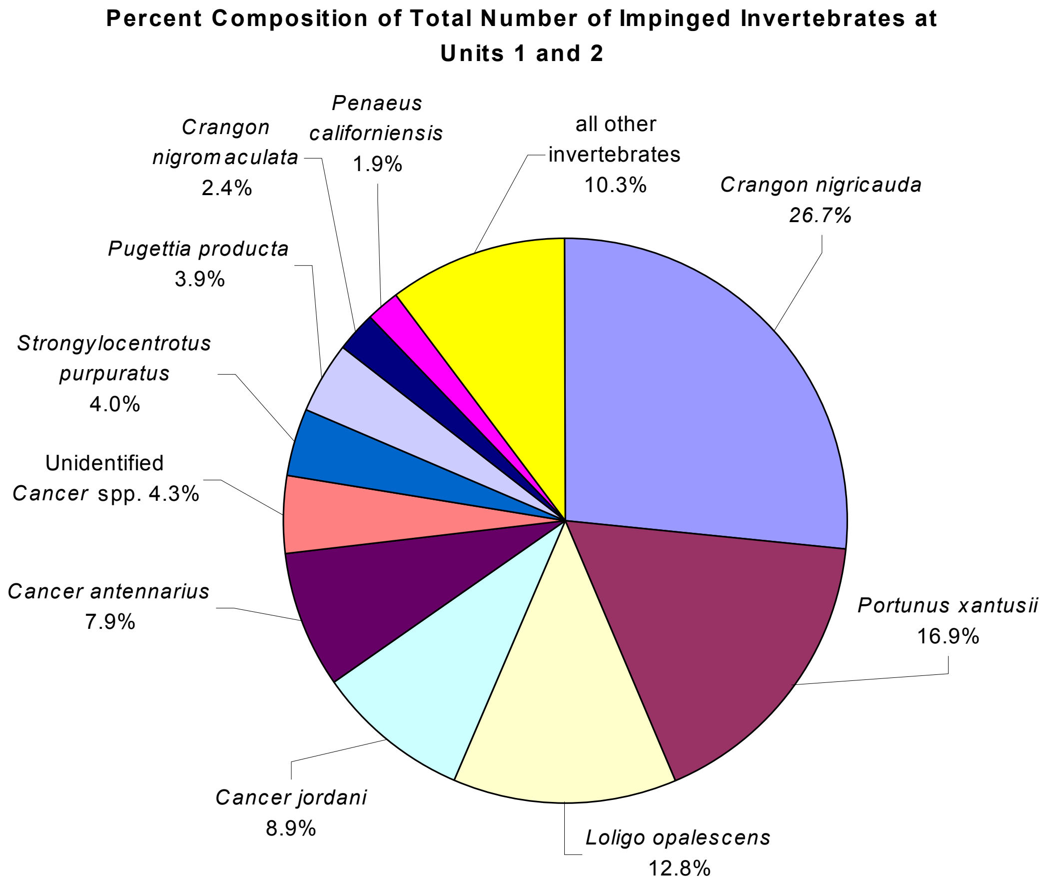


Figure 6-4b. Percent composition of impinged fishes at Morro Bay Power Plant Units 3 and 4 (September 9, 1999 through July 7, 2000).

(a)

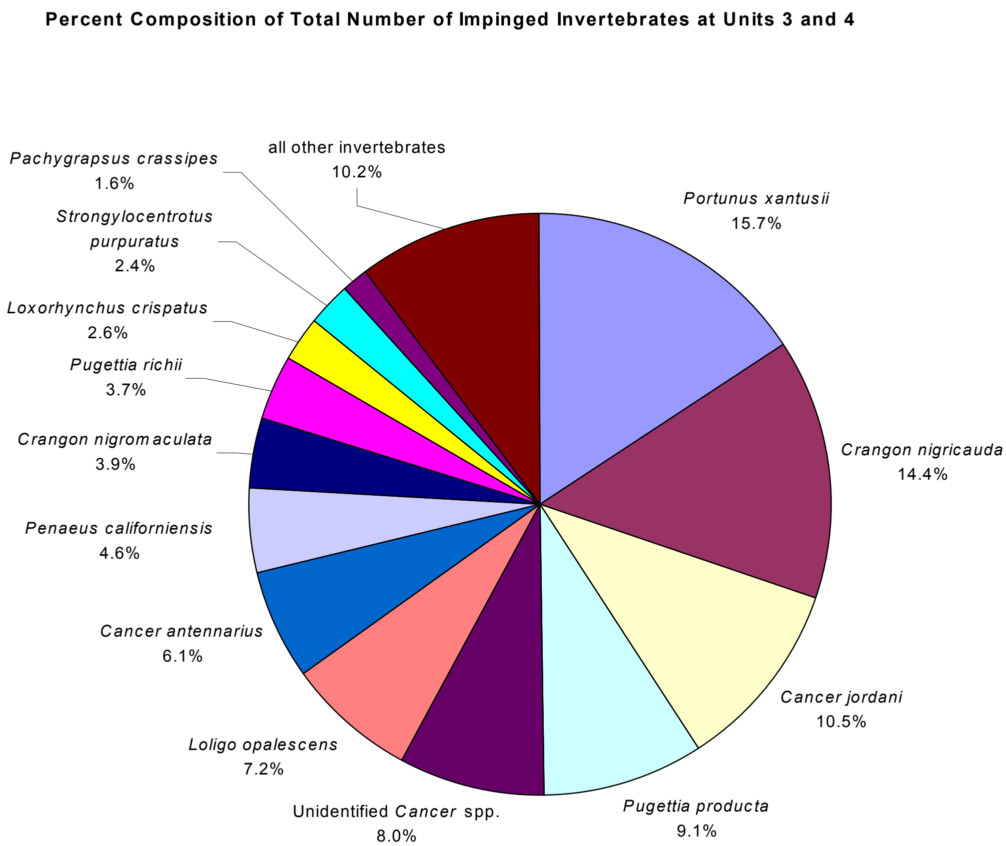


Data are preliminary because quality control checks are not complete.

Figure 6-5a. Percent composition of impinged invertebrates at Morro Bay Power Plant Units 1 and 2 (September 9, 1999 through July 7, 2000).

Note: Total does not add to 100 percent because of rounding.

(b)



Data are preliminary because quality control checks are not complete.

Figure 6-5b. Percent composition of impinged invertebrates at Morro Bay Power Plant Units 3 and 4 (September 9, 1999 through July 7, 2000).

7.0 IMPACT ASSESSMENT

Assessment of the population impacts of the MBPP's cooling water intake effects logically requires that the fractional losses represented by proportional entrainment or the number of reproductive females or equivalent adults be contrasted to the size of the at-risk resource. The theoretical number of adults that would have survived from larvae lost by entrainment or larger fishes by impingement is compared to the estimated number of individuals in the species population at risk. Knowing the fractional extent of these potential losses to a species' population provides the basis for determining the significance losses due to MBPP intake operations and technology. The theory and practice of 316(b) assessment is essentially the same as used in fisheries management to protect against any long-term decline in an exploited fish stock. In essence the fisheries manager must know the rate of harvest (entrainment and impingement), the size of the harvested population (number of larvae at risk to entrainment), and the reproductive capacity of the population including overproduction in compensation of high early life stage mortality.

Preliminary results of MBPP entrainment sampling indicate that the majority of entrained larvae are in the Family Gobiidae and cannot be identified to species. Population-level impact assessment must be species specific. However, this family of fish contains no species of any particular recreational or commercial value. Impacts of MBPP intake effects on species of entrained larvae that can be assessed according to the amount of available life history and demographic information. Northern anchovy, which are expected in the fall and late winter surveys, represent the best of species, in terms of impact assessment information. In general, very little information is available on the identifiable entrained species of gobies, such as the bay goby *Lepidigobius lepidus*, blackeye goby *Coryphopterus nicholsi*, and longjaw mudsucker *Gillichthys mirabilis*.

Our impact assessment of MBPP intake effects on entrained organisms will be limited by a general lack of species life history information. The extent and uncertainty of life history information, such as fecundity or life stage survivorship, about an entrained species takes the form of uncertainty in estimates of the extent of population level changes. Estimates of the extent of any entrainment impacts on resource populations are further limited by the quality and quantity of information available on taxa populations or harvested stocks. Both of the factors—species-specific life history and demographic information—contribute to the overall uncertainty in our estimates of long-term population trends. However, populations trends can be successfully forecasted with the use of working assumptions, many employed in fisheries management practices, that overcome some of the data and information gaps. While the importance of these data gaps is anticipated in the forthcoming MBPP intake impact assessment, a number of solutions are available depending upon the specific taxa entrained during the ongoing studies. To date, we have found that gobies are the most abundant family of larval fishes and unidentified gobies the largest taxa. Impact analysis cannot be performed on these unidentified gobies without knowledge of the species' life histories and demographics. Other remaining species of the most abundant larvae collected so far, such as Pacific staghorn sculpin, northern lampfish, and blackeye goby, will present information gaps. However, knowing the species identity of these entrained larvae enables the use of a number of working assumptions to address the gaps.

The range and variance estimates of life history parameters and population estimates create uncertainty in our assessments of intake effects for potential population level impacts. The available literature will be thoroughly researched for life history information to reduce the level of uncertainty by all possible and practical methods. While using the best information available in our impact assessment, we will also use sensitivity analysis to evaluate the degree of uncertainty in our estimates of entrainment effects and population impacts. The uncertainty of our estimates will be examined by the effects of varying values of input parameters on resulting computations. Results will provide insight into the possibility of improving our estimates with additional information. The sensitivity analyses will not only show the effects that the range of life history parameters can have on our estimates of entrainment effects, but they will also demonstrate the effect of sampling variance on the absolute ranges of our estimates. Annual estimates of *FH*, *AEL,* and *ETM* entrainment effects will be employed to estimate population level impacts. A range of annual *ETM* variance will be estimated using *PE*s (P_S) computed from previous source water larval fish surveys. The procedure will facilitate inter-annual variance estimates of population-level-impacts.

Values for the P_S parameter used for input to the *ETM* model will have large effects on our impact estimates of entrainment effects. For anchovy values of $P_{S,}$ we will use CalCOFI sampling regions presented in Lo (1985). These regions are used in the fisheries management of the central subpopulation of the anchovy that ranges from San Francisco, California to Punta Baja, Baja California (PFMC, 1990). For species that are not harvested or actively managed areas of potential impact will be defined based on duration of larval stages and ocean current speeds. The areal extent of larvae at risk will be determined by multiplying the number of days that a species' larvae are planktonic by current speeds in kilometers per day. This estimated distance traveled by the average larvae will be multiplied by the average depth over the reach of the species' travel, generally north to south along the coast, to determine the volume of the species' area at risk. This volume multiplied by the species' average larval concentration provides estimates of the species larval standing stocks required in *ETM* evaluations.

The sensitivity analyses for these species' areas at risk will demonstrate the effect that annual variations in current speed has on the size of this parameter and its contribution to the uncertainty in our estimates. The definition and selection of values for P_S for these and other species will be refined through further analysis of oceanographic data on the identity and movement (current velocity) of local water masses as might affect larval transport. Life history, habitat and demographic data on entrained species and taxa groups will be gathered over the next few months from CDFG and other sources, and discussions with the TWG members.

8.0 LITERATURE CITED

Boreman, J., C.P. Goodyear, and S.W. Christensen. 1978. An empirical transport model for evaluating entrainment of aquatic organism by power plants. United States Fish and Wildlife Service. FWS/OBS-78/90, Ann Arbor, MI.

Boreman, J., C.P. Goodyear, and S.W. Christensen. 1981. An empirical methodology for estimating entrainment losses at power plants sited on estuaries. Trans. Amer. Fish. Soc. 110:253-260.

Cowan, J.H., K.A. Rose, E.S. Rutherford, and E.D. Houde. 1993. Individual-based model of young-of-the-year striped bass population dynamics. II. Factors affecting recruitment in the Potomac River, Maryland. Trans. Am. Fish. Soc. 122: 439-458.

Fierstine, H.L., K.F. Kline, and G.R. Garman. 1973. Fishes collected in Morro Bay between January 1968 and December 1970. California Fish and Game Bulletin. 59(1): 73-88.

Goodyear, C.P. 1978. Entrainment impact estimates using the equivalent adult approach. United States Fish and Wildlife Service, FWS/OBS-78/65, Ann Arbor, MI.

Hewitt, R.D. 1982. Spatial pattern and survival of anchovy larvae: implications of adult reproductive strategy. Ph.D. Thesis, Univ. of California, San Diego. 207 p.

Hewitt, R.D., and G.D. Brewer. 1983. Nearshore production of young anchovy. CalCOFI Rept. 24:235-244.

Hewitt, R.D., and R.D. Methot. 1982. Distributions and mortality of northern anchovy larvae in 1978 and 1979. CalCOFI Rept. 23:226-245.

Horn, M.H. 1980. Diel and seasonal variation in abundance and diversity of shallow water fish populations in Morro Bay, California. California Fish and Game Bulletin. 78(3): 759-770.

Horst, T.J. 1975. The assessment of impact due to entrainment of ichthyoplankton. *In*: S.B. Saila (*ed*.) Fisheries and Energy Production: A symposium. Lexington Books, D.C. Heath and Company, Lexington, MA. p. 107-118.

Krebs, C.J. 1989. Ecological Methodology. Harper and Row, New York. 65 pp.

Lo, N.C.H. 1983. Re-estimation of three parameters associated with anchovy egg and larval abundance: Temperature dependent hatching time; yolk-sac growth rate; and egg and larval retention in mesh nets. U.S. Dept. of Comm., NOAA NMFS SWFC-31, 38 p.

Lo, N.C.H. 1985. Egg production of the central stock of northern anchovy 1951-1983. Fish. Bull. 88:137-150.

Lo, N.C.H. 1986. Modeling life-stage-specific instantaneous mortality rates, an application to northern anchovy, *Engraulis mordax*, eggs and larvae. Fish. Bull. 84(2): 395-407.

MacCall, A.D., K.R. Parker, R. Leithiser, and B. Jessee. 1983. Power plant impact assessment: A simple fishery production model approach. Fish. Bull. 81(3): 613-619.

McGurk, M.D. 1986. Natural mortality of marine pelagic fish eggs and larvae: role of spatial patchiness. Mar. Ecol. Prog. Ser. 34:227-242.

Murdoch, W.W., R.C. Fay, and B.J. Mechalas. 1989. Final Report of the Marine Review Committee to the California Coastal Commission, MRC Doc. No. 89-02, 346 p.

Nisbet, R.M., W.W. Murdoch, and A. Stewart-Oaten. 1996. Consequences for adult fish stocks of human-induced mortality of immatures. Pgs. 257-277 In: *Detecting Ecological Impacts: Concepts and Applications in Coastal Habitats*. Schmitt, R.J., and C.W. Osenberg (editors). 401 pp.

Pacific Fishery Management Council (PFMC). 1990. Sixth Amendment to the Northern Anchovy Fishery Management Plan. Portland, Oregon. 68 pp.

Pacific Gas & Electric Company (PG&E). 1973. An evaluation of the effect of cooling water discharges on the beneficial uses of receiving waters at Morro Bay Power Plant. PG&E, San Francisco, CA.

Pacific Gas & Electric Company (PG&E). 1982. Impingement Studies at Morro Bay Power Plant. PG&E, Department of Engineering Research, San Ramon, CA.

Parker, K.R. 1980. A direct method for estimating northern anchovy, *Engraulis mordax*, spawning biomass. Fish. Bull., U.S. 78:541-544.

Parker, K.R. and E. DeMartini. 1989. D. Adult-equivalent loss. Technical Report to the California Coastal Commission, Marine Review Committee, Inc. 56 p.

Public Service Electric and Gas Company. 1993. Appendix I—Modeling. Permit No. NJ0005622. Prepared by Lawler, Matusky, and Skelly Engineers, Pearl River, NY. Comments on NJPDES Draft. 82 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board. Can. Bull. 91. 382 p.

Saila, S.B., E. Lorda, J.D. Miller, R.A. Sher, and W.H. Howell. 1997. Equivalent adult losses of fish eggs, larvae and juveniles at Seabrook Station with use of fuzzy logic to represent parametric uncertainty. N. Amer. J. Fish. Man. 17(4): 811-825.

Smith, P.E. and S.L. Richardson. 1977. Standard techniques for pelagic fish egg and larva surveys. FAO Fisheries Tech. Paper 175: 1-100.

Summers, K.J. 1989. Simulating the indirect effects of power plant entrainment losses on an estuarine ecosystem. Ecol. Model. 49:31-47.

TENERA Environmental. 2000. Morro Bay Power Plant 316(b) Fourth Quarterly Report. Prepared for Duke Energy North America, Morro Bay LLC.

Tetra Tech, Inc. 1999. Morro Bay National Estuary Program Hydrodynamic Circulation Model. Final Report. Lafayette, CA.

U.S. Environmental Protection Agency (USEPA). 1976. Development Document for Best Technology Available for the Location, Design, Construction, and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. EPA-440/1-76/015a. 263 pp.

U.S. Environmental Protection Agency (USEPA). 1977. Guidance for evaluating the adverse impact of cooling water intake structures on the aquatic environment: Section 316(b) P.L. 92-500. 58 p.

Van Winkle, W., K.A. Rose, and R.C. Chambers. 1993. Individual-based approach to fish population dynamics: an overview. Trans. Am. Fish Soc. 122: 397-403.

Zweifel, J.R., and P.E. Smith. 1981. Estimates of abundance and mortality of larval anchovies (1951-1975). Rapp. P.-v. Reun. Cons. int. Explor. Mer. 178:248-259.

Appendix A

Estimating Total Annual Entrainment

An estimate of total annual larval entrainment at an intake source can be expressed as

$$\hat{E} = \sum_{i=1}^{L}\left[\frac{D_i}{d_i}\sum_{j=1}^{d_i}\left[\sum_{k=1}^{6}\frac{V_{ijk}}{2}\sum_{l=1}^{2}x_{ijkl}\right]\right] \tag{A1}$$

where

x_{ijkl} = measured density of larvae in the *l*th tow $(l = 1,\ 2)$ within the *k*th cycle $(k = 1,\ldots,6)$ on the *j*th day $(j = 1,\ldots, D_i)$ in the *i*th stratum $(i = 1,\ldots, L)$;

V_{ijk} = total water intake during the *k*th cycle $(k = 1,\ldots,6)$ from the *j*th day $(j = 1,\ldots, D_i)$ in the *i*th stratum $(i = 1,\ldots, L)$;

D_i = number of sampling days in the *i*th stratum of which d_i are sampled (nominally $d_i = 2$).

Here, a temporal stratum will be defined as a 2- or 4-week period (i.e., depending on time of year) where in 2 days are selected for sampling. Equation (A1) can also be expressed in terms of a volume-adjusted estimate where

$$\hat{E} = \sum_{i=1}^{L}\left[\frac{V_{Ti}}{V_i}\sum_{j=1}^{d_i}\left[\sum_{k=1}^{6}\frac{V_{ijk}}{2}\sum_{l=1}^{2}x_{ijkl}\right]\right] \tag{A2}$$

and where

$$V_i = \sum_{j=1}^{d_i}\ \sum_{k=1}^{6}V_{ijk}$$

$$V_{Ti} = \sum_{j=1}^{D_i}\sum_{k=1}^{6}V_{ijk}$$

Nominally, d_i will be 2 days for all temporal stratum. The variance of $\hat{E}$ [i.e., Equation (A2)] can be expressed as

$$Var\left(\hat{E} \mid E\right) = \sum_{i=1}^{L} \left\{ \left(\frac{V_{Ti}}{V_i} \right)^2 \left[\frac{d_i^2 \left(1 - \frac{d_i}{D_i} \right) S_{E_{ij}}^2}{d_i} + \frac{d_i}{D_i} \sum_{j=1}^{D_i} \sum_{k=1}^{6} V_{ijk}^2 \frac{S_{x_{ijkl}}^2}{2} \right] \right\} \tag{A3}$$

where

$$S_{x_{ijkl}}^2 = \frac{\sum_{l=1}^{N_{ijk}} \left(x_{ijkl} - \overline{X}_{ijk} \right)^2}{\left(N_{ijk} - 1 \right)};$$

$$\overline{X}_{ijk} = \frac{\sum_{l=1}^{N_{ijk}} x_{ijkl}}{N_{ijk}};$$

N_{ijk} = total number of tows possible during the kth cycle $(k = 1, \ldots, 6)$ of the jth day $\left(j = 1, \ldots, d_i \right)$ in the ith $(i = 1, \ldots, L)$ stratum;

and where

$$S_{E_{ij}}^2 = \frac{\sum_{j=1}^{D_i} \left(E_{ij} - \overline{E}_i \right)^2}{\left(D_i - 1 \right)};$$

E_{ij} = total entrainment during the jth day $\left(j = 1, \ldots, D_i \right)$ in the ith stratum $(i = 1, \ldots, L)$;

$$\overline{E}_i = \frac{\sum_{j=1}^{D_i} E_{ij}}{D_i}.$$

Variance (A3) is based on the assumption that d_i are a random sample from D_i days in the ith stratum $(i = 1, \ldots, L)$. The variance also assumes the 2 tow volumes are a random sample of the intake water during the kth cycle $(k = 1, \ldots, 6)$ of the jth day $\left(j = 1, \ldots, d_i \right)$. An unbiased variance estimator can be expressed (Appendix A) as

$$Var\left(\hat{E} \mid E\right) = \sum_{i=1}^{L} \left\{ \left(\frac{V_{Ti}}{V_i} \right)^2 \left[d_i \left(1 - \frac{d_i}{D_i} \right) S_{E_{ij}}^2 + \frac{d_i}{D_i} \sum_{j=1}^{d_i} \sum_{k=1}^{6} V_{ijk}^2 \frac{V_{ijk}^2 S_{x_{ijkl}}^2}{2} \right] \right\} \tag{A4}$$

and where

$$s^2_{\hat{E}_{ij}} = \frac{\sum_{j=1}^{d_i}\left(\hat{E}_{ij} - \hat{\bar{E}}_i\right)^2}{\left(d_i - 1\right)},$$

$$\hat{\bar{E}}_i = \frac{\sum_{j=1}^{d_i}\hat{E}_{ij}}{d_i},$$

and further

$$s^2_{x_{ijkl}} = \frac{\sum_{l=1}^{2}\left(x_{ijkl} - \bar{x}_{ijk}\right)^2}{(2-1)},$$

$$\bar{x}_{ijk} = \frac{\sum_{l=1}^{2}x_{ijkl}}{2}.$$

The estimator for total annual entrainment for the Morro Bay Power Plant $(\hat{E}_T)$ can then be written as

$$\hat{E}_T = \hat{E}_{1-2}$$

where $\hat{E}_{1-2}$ is the estimate of total annual entrainment at Units 1 and 2 based on repeated use of Equation (2). The variance for the estimator of total annual power plant entrainment can then be written as

$$V\hat{a}r\left(\hat{E}_T \mid E_T\right) = V\hat{a}r\left(\hat{E}_{1-2} \mid E_{1-2}\right) \tag{A5}$$

Estimates of E_T will be used in *FH* and *AEL* calculations to estimate annual effects of entrainment on fish and cancer crab stocks.

Appendix B

Derivation of the Variance and Estimated Variance of $\hat{E}$

Variance of $\hat{E}$

The variance of $\hat{E}$ can be derived by taking the variance in stages by first conditioning on the choice of d_i days, then taking expectation over all selections of d_i of D_i days within the temporal stratum.

$$
\begin{aligned}
Var(\hat{E}) &= E_{d_i}\left[Var(\hat{E}|d_i)\right] + Var_{d_i}\left[E(\hat{E}|d_i)\right] \\
&= E_{d_i}\left[Var\left(\sum_{i=1}^{L}\left(\frac{V_{Ti}}{V_i}\right)\sum_{j=2}^{d_i}\frac{V_{ijk}}{2}\sum_{l=1}^{2}x_{ijkl}\right)\right] \\
&\quad + Var_{d_i}\left[E\left(\sum_{i=1}^{L}\left(\frac{V_{Ti}}{V_i}\right)\sum_{j=1}^{d_i}\left[\sum_{k=1}^{4}\frac{V_{ijk}}{2}\sum_{l=1}^{2}x_{ijkl}\right]\right)\right] \\
&= E_{d_i}\left[\sum_{i=1}^{L}\left(\frac{V_{Ti}}{V_i}\right)^2\sum_{j=1}^{d_i}\sum_{k=1}^{4}\frac{V_{ijk}^2\left(1-\frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2}\right] + Var_{d_i}\left[\sum_{i=1}^{L}\left(\frac{V_{Ti}}{V_i}\right)\sum_{j=1}^{d_i}E_{ij}\right] \qquad \text{(B1)} \\
&= \sum_{i=1}^{L}\left(\frac{V_{Ti}}{V_i}\right)^2\frac{d_i}{D_i}\sum_{j=1}^{D_i}\sum_{k=1}^{4}\frac{V_{ijk}^2\left(1-\frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2} + \sum_{i=1}^{L}\left[\left(\frac{V_{Ti}}{V_i}\right)^2\frac{d_i^2\left(1-\frac{d_i}{D_i}\right)S_{E_{ij}}^2}{d_i}\right] \\
&= \sum_{i=1}^{L}\left\{\left(\frac{V_{Ti}}{V_i}\right)^2\left[\frac{d_i^2\left(1-\frac{d_i}{D_i}\right)S_{E_{ij}}^2}{d_i} + \frac{d_i}{D_i}\sum_{j=1}^{D_i}\sum_{k=1}^{4}V_{ijk}^2\frac{\left(1-\frac{2}{N_{ij}}\right)S_{x_{ijkl}}^2}{2}\right]\right\}
\end{aligned}
$$

where

$$S_{E_{ij}}^2 = \frac{\sum_{j=1}^{D_i}\left(E_{ij} - \overline{E}_i\right)^2}{\left(D_i - 1\right)},$$

$$\overline{E}_i = \frac{\sum_{j=1}^{D_i} E_{ij}}{D_i},$$

and where

$$S_{x_{ijkl}}^2 = \frac{\sum_{l=1}^{N_{ij}}\left(x_{ijkl} - \overline{X}_{ijk}\right)^2}{\left(N_{ij} - 1\right)},$$

$$X_{ijk} = \frac{\sum_{l=1}^{N_{ijkl}} x_{ijkl}}{N_{ijkl}},$$

and furthermore

$$E_{ij} = \sum_{k=1}^{4}\sum_{l=1}^{N_{ijkl}} x_{ijkl} = \text{total entrainment for the } j\text{th day } (j = 1, \ldots, D) \text{ in the } i\text{th stratum}$$

$$(i = 1, \ldots, L).$$

The finite population correction [i.e., $\left(1 - \frac{2}{N_{ijk}}\right)$] will be nearly one in all cases and can be ignored.

Estimated Variance of $\hat{E}$

The variance for $\hat{E}$ is

$$Var\left(\hat{E}\middle|E\right) = \sum_{i=1}^{L}\left\{\left(\frac{V_{Ti}}{V_i}\right)^2\left[d_i\left(1 - \frac{d_i}{D_i}\right)S_{E_{ij}}^2 + \frac{d_i}{D_i}\sum_{j=1}^{D_i}\sum_{k=1}^{4} V_{ijk}^2 \frac{\left(1 - \frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2}\right]\right\}. \qquad \text{(B2)}$$

The term

$$\frac{d_i}{D_i}\sum_{j=1}^{D_i}\sum_{k=1}^{4} V_{ijk}^2 \frac{\left(1-\frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2}$$

in Equation (B2) can be unbiasedly estimated by the quantity

$$\sum_{j=1}^{d_i}\sum_{k=1}^{4} V_{ijk}^2 \frac{\left(1-\frac{2}{N_{ijk}}\right)s_{x_{ijkl}}^2}{2} \qquad \text{(B3)}$$

when

$$s_{x_{ijkl}}^2 = \frac{\sum_{l=1}^{2}\left(x_{ijkl}-\bar{x}_{ijk}\right)^2}{(2-1)}.$$

However,

$$E\left(s_{\hat{E}_{ij}}^2\right) \neq S_{E_{ij}}^2 \ .$$

Instead,

$$Var\left(\hat{E}_{ij}\right) = Var\left(\sum_{k=1}^{4}\frac{V_{ijk}}{2}\sum_{l=1}^{2} x_{ijkl}\right)$$

taking the variance in stages

$$\begin{aligned}
Var\left(\hat{E}_{ij}\right) &= E_{d_i}\left[Var\left(\hat{E}_{ij}\middle|d_i\right)\right] + Var_{d_i}\left[Var\left(\hat{E}_{ij}\middle|d_i\right)\right] \\
&= E_{d_i}\left[Var\left(\sum_{k=1}^{4}\frac{V_{ijk}}{2}\middle|\sum_{l=1}^{2} x_{ijkl}\middle|d_i\right)\right] + Var_{d_i}\left[Var\left(\sum_{k=1}^{4}\frac{V_{ijk}}{2}\middle|\sum_{l=1}^{2} x_{ijkl}\middle|d_i\right)\right] \\
&= E_{d_i}\left[\sum_{k=1}^{4}\frac{V_{ijk}^2\left(1-\frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2}\right] + Var_{d_i}\left[E_{ij}\right] \\
&= \left[\frac{1}{D_i}\sum_{j=1}^{D_i}\sum_{k=1}^{4}\left[\frac{V_{ijk}^2\left(1-\frac{2}{N_{ijk}}\right)S_{x_{ijkl}}^2}{2}\right]\right] + S_{E_{ij}}^2 \ .
\end{aligned}$$

Hence,

$$E\left[d_i\left(1-\frac{d_i}{D_i}\right)s^2_{\hat{E}_{ij}}\right]=d_i\left(1-\frac{d_i}{D_i}\right)S^2_{E_{ij}}+\frac{d_i}{D_i}\left(1-\frac{d_i}{D_i}\right)\sum_{j=1}^{D_i}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ij}}\right)S^2_{x_{ijk}}}{2} \qquad \text{(B4)}$$

which has a positive bias of

$$\frac{d_i}{D_i}\left(1-\frac{d_i}{D_i}\right)\sum_{j=1}^{D}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ijk}}\right)S^2_{x_{ijk}}}{2} \qquad \text{(B5)}$$

In turn, the bias (B5) can be estimated by the quantity

$$\left(1-\frac{d_i}{D_i}\right)\sum_{j=1}^{d_i}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ijk}}\right)s^2_{x_{ijk}}}{2}. \qquad \text{(B6)}$$

An estimator of $Var\left(\hat{E}\middle|E\right)$ can then be expressed by taking into account Equations (B3-B6) as

$$\hat{Var}\left(\hat{E}\middle|E\right)=\sum_{i=1}^{L}\left\{\left(\frac{V_{Ti}}{V_i}\right)^2\left[d_i\left(1-\frac{d_i}{D_i}\right)s^2_{E_{ij}}-\left(1-\frac{d_i}{D_i}\right)\sum_{j=1}^{d_i}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ijk}}\right)s^2_{x_{ijk}}}{2}\right]\right.$$

$$\left.+\sum_{j=1}^{d_i}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ijk}}\right)s^2_{x_{ijk}}}{2}\right\}$$

$$=\sum_{i=1}^{L}\left\{\left(\frac{V_{Ti}}{V_i}\right)^2\left[d_i\left(1-\frac{d_i}{D_i}\right)s^2_{E_{ij}}+\frac{d_i}{D_i}\sum_{j=1}^{d_i}\sum_{k=1}^{4}\frac{V^2_{ijk}\left(1-\frac{2}{N_{ijk}}\right)s^2_{x_{ijk}}}{2}\right]\right\}.$$

Appendix C

Estimating Proportional Entrainment and the *ETM* Calculations

The empirical transport model (*ETM*) is used to estimate the total annual mortality probability for larvae from power plant entrainment. The annual estimate is based on periodic daily probabilities of entrainment mortality. The calculations will assume all larvae entrained die.

The daily probability of entrainment can be defined as

$$\begin{aligned} P_{M_{ij}} &= \frac{\text{abundance of entrained larvae}_{\text{ij}}}{\text{abundance of larvae in source population}_{\text{ij}}} \\ &= \text{probability of entrainment on the } j\text{th day } \left(j = 1, \ldots, d_i\right) \\ &\quad \text{of the } i\text{th temporal stratum } (i = 1, \ldots, L). \end{aligned}$$

In turn, the daily probability can be estimated and expressed as

$$P_{M_{ij}} = \frac{\hat{E}_{ij}^{T}}{\hat{R}_{ij}} \qquad \text{(C1)}$$

where

$\hat{E}_{ij}^{T}$ = estimated abundance of larvae entrained on the jth day $\left(j = 1, \ldots, d_i\right)$ of the ith stratum $(i = 1, \ldots, L)$;

$\hat{R}_{ij}$ = estimated abundance of larvae at risk of entrainment from the source populations on the jth day $\left(j = 1, \ldots, d_i\right)$ of the ith stratum $(i = 1, \ldots, L)$.

Estimating Daily Entrainment

The estimate of total daily entrainment $\left(E_{ij}^{T}\right)$ at Units 1 and 2 can be written as

$$\hat{E}_{ij}^{T} \qquad \text{(C2)}$$

The estimate of MBPP entrainment can be expressed as

$$\hat{E}_{ij} = \sum_{k=1}^{4} \frac{V_{jk}}{2} \sum_{l=1}^{2} x_{ijkl} \qquad \text{(C3)}$$

with associated variance

$$Var\left(\hat{E}_{ij} \middle| E_{ij}\right) = \sum_{k=1}^{4} \frac{V_{jk}^{2}\left(1 - \frac{2}{N_{ijk}}\right) S_{x_{ijk;}}^{2}}{2} \qquad \text{(C4)}$$

which can be estimated by

$$V\hat{a}r\left(\hat{E}_{ij} \middle| E_{ij}\right) = \sum_{k=1}^{4} V_{jk}^{2} \frac{\left(1 - \frac{2}{N_{ijk}}\right) s_{x_{ijkl}}^{2}}{2}. \qquad \text{(C5)}$$

Typically, the finite population correction [i.e., $\left(1 - \frac{2}{N_{ijk}}\right)$] can be ignored for N_{ijk} is exceedingly large.

Estimating Daily Numbers of Larvae at Risk

With the well-defined and agreed-upon sources of Morro Bay (MB) and Estero Bay (EB) larvae, the daily abundance of larvae at risk can be estimated by

$$\hat{R}_{ij} = V_{MB} \cdot \hat{\bar{D}}_{MB_{ij}} + V_{EB} \cdot \hat{\bar{D}}_{EB_{ij}} \qquad \text{(C6)}$$

where V denotes daily exchanged and static volumes at Morro Bay (MB) or static volume of Estero Bay (EB), and $\hat{\bar{D}}$ denotes an estimate of average density in each respective source water bodies. The variance of Expression (C6) can be written as

$$Var\left(\hat{R}_{ij} \mid R_{ij}\right) = V_{MB}^2 \cdot Var\left(\hat{\bar{D}}_{MB_{ij}} \mid \bar{D}_{MB_{ij}}\right) + V_{EB}^2 \cdot Var\left(\hat{\bar{D}}_{EB_{ij}} \mid \bar{D}_{EB_{ij}}\right) \qquad \text{(C7)}$$

The individual variances within Formula (C7) describe temporal-spatial variance in density within a source population during the day of sampling. Three source water locations are sampled in Morro Bay not including the MBPP and one location is sampled in the Estero Bay. Ideally, tow samples would be collected probablistically through time and space during a sampling day at a potential source population. However, practical limitations of sampling these distances required a fixed time and location sampling scheme.

Variance for Daily Estimate of PM_{ij}

The variance for the daily estimate of $\hat{P}M_{ij}$ can be expressed as

$$Var\left(\hat{P}M_{ij} \middle| PM_{ij}\right) \doteq Var\left(\frac{\hat{E}_{ij}}{\hat{R}_{ij}} \middle| E_{ij}, R_{ij}\right)$$

which by the Delta method can be approximated by

$$Var\left(\hat{P}M_{ij} \middle| PM_{ij}\right) \doteq \left(\frac{E_{ij}}{R_{ij}}\right)^2 \left[\frac{Var\left(\hat{E}_{ij} \middle| E_{ij}\right)}{E_{ij}^2} + \frac{Var\left(\hat{R}_{ij} \middle| R_{ij}\right)}{R_{ij}^2}\right] \qquad \text{(C8)}$$

and can be estimated by

$$V\hat{a}r\left(\hat{P}M_{ij} \middle| PM_{ij}\right) = \left(\hat{P}M_{ij}\right)^2 \left[\hat{C}V\left(\hat{E}_{ij} \middle| E_{ij}\right)^2 + \hat{C}V\left(\hat{R}_{ij} \middle| R_{ij}\right)^2\right]$$

where

$$\hat{C}V\left(\hat{\theta}\middle|\theta\right)=\frac{V\hat{a}r\left(\hat{\theta}\middle|\theta\right)}{\hat{\theta}^2}.$$

ETM Calculations

By combining Equations (C1), (C2), and (C6), the estimate of daily entrainment mortality can be written as

$$\begin{aligned}\hat{P}_{M_{ij}} &= \frac{\hat{E}_{ij}^{T}}{\left(V_{MB}\cdot\hat{\bar{D}}_{MB_{ij}}+V_{EB}\cdot\hat{\bar{D}}_{EB_{ij}}\right)}\\ &= \frac{\hat{E}_{ij}}{\hat{R}_{ij}}\end{aligned} \tag{C9}$$

If the species has a single spawning period per year, then the estimate of total annual entrainment mortality can be expressed by

$$\hat{P}M = 1-\prod_{i=1}^{L}\prod_{j=1}^{d_i}\left(1-\hat{P}M_{ij}\right)^{D'_{ij}} \tag{C10}$$

where

D'_{ij} = number of days represented by the jth sample $\left(j=1,\ldots,d_i\right)$ in the ith temporal stratum $\left(i=1,\ldots,L\right)$.

Alternatively, if the species has multiple overlapping spawnings, then an estimate of total annual entrainment can be based on the formula

$$\hat{P}M = 1-\sum_{i=1}^{L}\sum_{j=1}^{d_i}\hat{f}_{ij}\left(1-\hat{P}M_{ij}\right)^{D'_{ij}} \tag{C11}$$

where

$\hat{f}_{ij}$ = estimated annual fraction of total larvae hatched during the survey period represented by the *j*th sample in the *i*th temporal stratum.

Formula (C11) is based on the total probability law where

$$P(A) = \sum_{i=1}^{N} P(A|B_i) \cdot P(B_i).$$

In the above example, the event A is larval survival and event B is hatching with $P(B)$ estimated by $\hat{f}_{ij}$.

Appendix D
Delta Method for Calculating Variance

Variance for $P\hat{E}_i$

Using the delta method (Seber, 1984), variance of $P\hat{E}_i$ can be effectively approximated by

$$Var(P\hat{E}_i) = Var\left(\frac{\hat{N}}{(1+\hat{f})\hat{A}_i}\right)$$

$$= Var(\hat{N}_i)\left(\frac{1}{(1+f_i)A_i}\right)^2 + Var(\hat{f}_i)\left(\frac{-N_i}{A_i(1+f_i)^2}\right)^2$$

$$+ Var(A_i)\left(\frac{-N_i}{(1+f)A_i^2}\right)^2$$

$$= \left(\frac{-N_i}{(1+f_i)A_i}\right)^2\left[\frac{Var(\hat{N}_i)}{N_i^2} + \frac{Var(\hat{f}_i)}{(1+f_i)^2} + \frac{Var(\hat{A}_i)}{A_i^2}\right]$$

$$= PE_i^2[CV(\hat{N}_i)^2 + CV(1+\hat{f})^2 + CV(\hat{A}_i)^2] \quad .$$

Variance for S_A

Survival to adult can be estimated from

$$\hat{S}_A = \frac{2}{\hat{F}\cdot\hat{R}\cdot\hat{S}_E\cdot\hat{S}_L}$$

where:

$\hat{\bar{F}} =$ average egg mass per female per year;

$\hat{R} =$ reproduction longevity, average number of years of reproduction for a female;

$\hat{S}_E =$ egg survival rate;

$\hat{S}_L =$ survival of larvae from hatching to time of entrainment.

The variance of $\hat{S}_A$ based on the delta method is then estimated by the approximate formula

$$V\hat{a}r(\hat{S}_A) = S_A^2\left[\frac{V\hat{a}r(\hat{\hat{F}})}{\hat{F}^2} + \frac{V\hat{a}r(\hat{R})}{\hat{R}^2} + \frac{V\hat{a}r(\hat{S}_E)}{\hat{S}_E^2} + \frac{V\hat{a}r(\hat{S}_L)}{\hat{S}_L^2}\right] .$$

For the example of monkeyface eel, the variance of $\hat{S}_A$ is estimated as

$$\begin{aligned} Var(\hat{S}_A) &= (0.0001388)^2\left[\frac{(4{,}667)^2}{(32{,}000)^2} + \frac{(2.08)^2}{(11.75)^2} + \frac{(0.0373)^2}{(0.4240)^2} + \frac{(0.0314)^2}{(0.0904)^2}\right] \\ &= 0.0000000035 \end{aligned}$$

or

$$\hat{S}E(\hat{S}_A) = 0.00005905 \quad .$$

Variance for $A\hat{E}L$

The estimator of adult equivalent loss is

$$A\hat{E}L = \hat{E}_T \cdot \hat{S}_A$$

with exact variance

$$Var(A\hat{E}L) = Var(\hat{E}_T)\cdot S_A^2 + Var(\hat{S}_A)^2 \cdot E_T^2 + Var(\hat{E}_T)^2 \cdot Var(\hat{S}_A) \quad .$$

Using the variance formula in conjunction with the monkeyface eel data results in an estimated variance of

$$\begin{aligned} V\hat{a}r(A\hat{E}L) &= (197{,}677{,}101)^2(0.0001388)^2 + (0.00005905)^2(160{,}544{,}555)^2 + (192{,}677{,}101)^2(0.00005905) \\ &= 934{,}541{,}905.8 \end{aligned}$$

or

$$\hat{S}E(A\hat{E}L) = 30{,}570.3 \quad .$$

Variance for $\hat{F}H$

The estimator of hindcast fecundity lost is

$$\hat{F}H = \frac{\hat{E}_T}{\hat{S}_E \cdot \hat{S}_L \cdot \hat{\hat{F}}_T}$$

where

$\hat{E}_T =$ estimated total entrainment of larvae;

$\hat{S}_E =$ survival probability for eggs;

$\hat{S}_L =$ survival of larvae from hatching to time of entrainment;

$\hat{\bar{F}}_T =$ estimated average total lifetime fecundity $= \hat{F} \cdot \hat{R}$.

Using the Delta method, an approximate variance estimator is

$$V\hat{a}r(\hat{F}H) = FH^2 \left[\frac{V\hat{a}r(\hat{E}_T)}{\hat{E}_T^{\ 2}} + \frac{V\hat{a}r(\hat{S}_E)}{\hat{S}_E^{\ 2}} + \frac{V\hat{a}r(\hat{S}_L)}{\hat{S}_L^2} + \frac{V\hat{a}r(\hat{F})}{\hat{F}^2} + \frac{V\hat{a}r(\hat{R})}{\hat{R}^2} \right] \ .$$

For the example of monkeyface eel, the variance of $\hat{F}H$ is calculated to be

$$V\hat{a}r(\hat{F}H) = (11{,}140)^2 \left[\frac{(192{,}677{,}101)^2}{(160{,}544{,}555)^2} + \frac{(0.0373)^2}{(0.4240)^2} + \frac{(0.0314)^2}{(0.0904)^2} + \frac{(4{,}667)^2}{(32{,}000)^2} + \frac{(2.08)^2}{(11.75)^2} \right]$$

$$= 201{,}208{,}630$$

or

$$\hat{S}E(\hat{F}H) = 14{,}184.8 \ .$$

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix A
Cooling Water Intake Study Plan

Attachment 1

MODEL PARAMETERIZATION

May 11, 2001

MODEL PARAMETERIZATION

The three methods for assessing cooling water system (CWS) effects on larval fishes and megalopal cancer crabs described in the MBPP Modernization Project Study Plan were fecundity hindcasting (*FH*), adult equivalent loss (*AEL*) and empirical transport modeling (*ETM*). The *FH* and *AEL* models are demographic approaches that rely almost entirely on life history information for their formulation. An estimate of larval growth rate that is used to determine the duration of exposure to entrainment is the only life history information needed for the formulation of the *ETM* approach. While this is an advantage of the *ETM*, all of the models require some estimate of the source water population for their interpretation. This appendix describes how life history information from the scientific and technical literature was used to parameterize these models. We use two taxa as examples, combtooth blennies *Hypsoblennius* spp. a bay species, and white croaker *Genyonemus lineatus* a coastal species.

1.0 Combtooth blennies

1.1 Empirical Transport Model

The calculation of *ETM*, illustrated in Equations 9 to 14, (Appendix C) requires that several parameters be obtained for each taxon being modeled. These include estimates of the number of larvae and megalops entrained, the number of larvae and megalops in the source water population at risk to entrainment, and an estimate of the period of time that the larvae are subject to entrainment. The period of time that the larvae are exposed to entrainment was estimated by applying a daily larval growth rate to the mean and maximum larval lengths from entrainment samples. The sample of larval combtooth blennies measured from entrainment samples had a mean length of 2.55 mm and a range from 2.0 to 3.2 mm (Figure 3-25 of the 316(b) Resource Assessment report). The upper 99 percentile value of the measurements used in calculating the maximum duration of larval exposure was 3.1 mm, while the lower 99 percentile value used as the minimum length was 2.0 mm. The period of time that the larvae are exposed to entrainment was estimated as follows:

$$\textit{Exposure Entrainment (days)} = \textit{(Mean or Max Length (mm)} - \textit{Minimum Length (mm))} \,/\, \textit{growth rate (mm/days)} \qquad (1)$$

For combtooth blennies a larval growth rate was estimated by averaging the growth rates (0.117, 0.19, 0.103 mm/d) from three sympatric species of blennies found in Stephens et al. (1970). A growth rate of 0.1367 mm/day was used to estimate the maximum period of time that combtooth blenny larvae would be exposed to entrainment as follows:

(2.55 mm - 2.0 mm) / 0.1367 mm/day = 4.0 days

The larval duration is then used in *ETM* to calculate an estimate of P_m, the annual probability of mortality due to entrainment. The data used to calculate an estimate of P_m are shown in Table 1. Estimates of the number of larvae in the source water population at risk to entrainment and the number of larvae entrained are combined to form an estimate of *PE* for each survey. The *PE* is an estimate of the conditional mortality on the source water population due to entrainment assuming that no other sources of mortality exist (Ricker 1975). The *PE* estimates from each survey are weighted by the fraction of the total entrainment (f_i) during the entire year that is subject to entrainment during the study period in order to form an annual-mortality estimate. The quantity $f_i \bullet (1-PE_i)^{duration}$ is an estimate of the probability that a larva has to escape entrainment based on data collected during the study period. A mortality estimate is formed by summing the weighted survey survivals and subtracting from one:

$$P_m = 1 - \sum_{i=1}^{12} f_i \cdot (1 - PE_i)^{duration} \tag{2}$$

An estimate of P_m = .49 was calculated for combtooth blennies.

Table 1. *ETM* data and example calculations for combtooth blennies *Hypsoblennius spp.*

Survey Date	Entrainment Estimate (#)	Entrainment Volume (m^3)	Morro Bay Estimate (#)	Morro Bay Volume (m3)	Morro Bay *PE*	Estero Bay Estimate (#)	Estero Bay Volume (m3)	Estero Bay *PE*	Total PE	f_i	Duration of Larval Exposure	$= f_i * (1-PE_i)^{duration}$
17-Jan-00	0	1,619,190	0	15,686,663	0.0000	0	20,915,551	0.0000	0.0000	0.0021	4.0	0.0021
28-Feb-00	0	1,619,190	5,939	15,686,663	0.0000	0	20,915,551	0.0000	0.0000	0.0069	4.0	0.0069
27-Mar-00	8,027	1,619,190	27,045	15,686,663	0.2968	13,167	20,915,551	0.6097	0.1996	0.0031	4.0	0.0013
24-Apr-00	0	1,619,190	4,870	15,686,663	0.0000	11,905	20,915,551	0.0000	0.0000	0.0023	4.0	0.0023
15-May-00	3,077	1,619,190	14,077	15,686,663	0.2186	14,488	20,915,551	0.2124	0.1077	0.0048	4.0	0.0030
12-Jun-00	10,700	1,619,190	71,704	15,686,663	0.1492	17,830	20,915,551	0.6001	0.1195	0.0266	4.0	0.0159
10-Jul-00	86,893	1,619,190	339,688	15,686,663	0.2558	136,063	20,915,551	0.6386	0.1826	0.2457	4.0	0.1088
8-Aug-00	158,591	1,619,190	527,532	15,686,663	0.3006	314,375	20,915,551	0.5045	0.1884	0.3702	4.0	0.1593
5-Sep-00	94,659	1,619,190	378,555	15,686,663	0.2501	258,424	20,915,551	0.3663	0.1486	0.2241	4.0	0.1170
2-Oct-00	18,889	1,619,190	124,399	15,686,663	0.1518	126,409	20,915,551	0.1494	0.0753	0.0832	4.0	0.0606
13-Nov-00	0	1,619,190	0	15,686,663	0.0000	0	20,915,551	0.0000	0.0000	0.0273	4.0	0.0273
18-Dec-00	0	1,619,190	0	15,686,663	0.0000	0	20,915,551	0.0000	0.0000	0.0038	4.0	0.0038

P_m Estimate = $1 - \Sigma(f_i * (1-PE_i)^{duration}) =$ **0.4917**

$PE_i = \textit{Entrainment Estimate}_i / (\textit{Morro Bay Estimate}_i + \textit{Estero Bay Estimate}_i)$

$f_i = \textit{Entrainment Estimate}_i / \textit{Total Annual Entrainment Estimate}$

1.2 Fecundity Hindcasting

In addition to estimates of the number of larvae entrained, the calculation of *FH*, illustrated in Appendix C of the Study Plan, requires that several life history values be obtained for each taxon modeled. These values are the age at entrainment, the egg and larval survival to entrainment, and lifetime fecundity for each taxon. Lifetime fecundity (*FT*) is calculated from estimates of annual fecundity and then applied to the average number of years a mature female is reproductive:

$$F_T = \overline{Eggs / year} \bullet \left(\frac{Longevity - Maturation}{2}\right) \qquad (3)$$

The estimate of *FH* is computed using the following formula:

$$FH = \frac{E_{Total}}{\prod_{j=1}^{n} S_j \bullet F_T}, \qquad (4)$$

where S_j represents the survival of the *j* life stages up through entrainment. These could include eggs, yolk-sac and later larval statges depending upon the life history of the taxa.

The life history values needed to estimate *FH* for combtooth blennies were compiled primarily from Stephens et al. (1970) studies on three sympatric species of blennies. Stephens et al. (1970) do not report estimates of egg survival. Egg masses in the group are demersal and attached to a nest site that is guarded by the male (Stephens et al. 1970). Therefore, egg survival is probably high and conservatively assumed to be 100 percent. Although no estimate of larval survival is available, Brothers (1975) indicates that 98.3 percent larval mortality over two months was a reasonable estimate for arrow goby. We assumed 99 percent larval mortality for combtooth blennies that occupy similar habitats. This estimate was used to calculate a daily survival rate for the estimated total larval duration of 2 to 3 months (Stephens et al. 1970) ($(1\text{-}0.99)^{1/75}$ = 0.940^{-d}). Survival to entrainment was then estimated using the mean number of days to entrainment (4.03 d) as $0.940^{4.03} = .78$. A fecundity estimate of 1180 eggs was used based on the estimates for *H. jenkinsi* in Stephens et al. (1970), and assuming that the maximum egg production of 1500 after three years occurs over the remaining average maximum lifespan of 7 years (500, 900, 1500, 1500, 1500, 1500). Based on the values from Stephens et al. (1970) the average age of maturity was assumed to be 2 years. *FH* for combtooth blennies was computed as follows:

$$FH = 4{,}361 = \frac{10{,}042{,}151}{(0.7805)(1{,}180)\frac{(7-2)}{2}}$$

1.3 Adult Equivalent Loss

The calculation of *AEL*, illustrated in Appendix C of the Study Plan, requires survival estimates for the various life stages from entrainment through recruitment as adults for each taxon being modeled. Survival rates are not available for most of the taxa we have collected, and survival rates for specific life stages are even less common. Therefore, in many cases a survival rate was applied across a number of life stages. For example, the single estimates of larval and adult survival obtained for combtooth blennies were applied over the period from entrainment through settlement (75 days) and the adult survival rate was applied from settlement to adulthood at age 3.3 years. This assumes that the adult survival rate applies to the various juvenile and pre-recruit stages. If survival rates for all the various life stages were available, then *AEL* would be calculated as follows:

$$AEL = (Entrainment_{total})\ (S_{Early\ Larvae})\ (S_{Late\ Larvae})\ (S_{Early\ Juv})\ (S_{Late\ Juv.})\ (S_{Pre\text{-}Recruits}) \qquad (5)$$

The formulation of an *AEL* estimate for combtooth blennies included larval survival from entrainment to settlement and survival from settlement to age 3.3 years, the average age of the adults between ages 2 and 7 estimated using the assumption of an exponentially decreasing population size. Larval survival from entrainment (4 days) to settlement (75 days) was estimated as $0.94^{75-4} = .0128$ using the same daily survival rate used in formulating *FH*. Adult mortality was estimated from age groupings of three species of blennies in Stephens et al. (1970). Exponential instantaneous mortality rates (Z) were calculated from these age groupings using the relationship between log numbers at age $\ln(N_t)$ and age t:

$$\ln(N_t) = -Zt + b. \qquad (6)$$

The average of the instantaneous mortality rates (*H. jenkinsi*: Z=0.72; *H. gilberti*: Z=0.57; *H. gentilis*: Z=0.64) was used to estimate annual adult survival at 0.525 yr^{-1}. Using this annual rate, the survival from settlement (75 days) to age 3.3 years was estimated as $0.525^{3.3\ yr} = 0.1361$. *AEL* for numbers of combtooth blennies entrained in 12 months was computed as follows:

$$AEL = 17{,}516 = (10{,}042{,}151)\ (0.0128)\ (0.1361)$$

2.0 White Croaker

2.1 Empirical Transport Model

The period of time that the larvae are exposed to entrainment used as an exponent in the calculation of *ETM* was estimated for white croaker using Equation 7. The sample of white croaker larvae measured from entrainment samples had a mean length of 2.8 mm and a range of 1.2 to 7.6 mm. The upper 99 percentile value of the measurements used in calculating the maximum duration of larval exposure was 6.1 mm, while the lower 99 percentile value used as the minimum length was 1.4 mm. A growth rate of 0.20 mm/day (Murdoch et al. 1989) was used to estimate a maximum period of entrainment risk of 23.5 days, while the duration to the mean length of 2.8 mm was estimated as 6.9 days.

$$(2.81\ mm - 1.42\ mm)\ /\ 0.20\ mm/day = 6.9\ days \qquad (7)$$

The larval duration is then used in *ETM* to calculate a probability of survival, the first step in estimating P_m, the annual probability of mortality due to entrainment using the data shown in Table 2.

Combtooth blennies are primarily bay species, but white croaker occur in bays and estuaries and also in sandy nearshore areas less than 30 m deep (Streamnet 1999). In addition, white croaker can be found out to depths of 100 m (Frey 1971). Therefore, Equation 2 is modified for white croaker and other taxa that have local source populations that are not primarily distributed in Morro Bay. The following equation (8) for *ETM* employs a correction, P_s, for local source population sampled in the source water studies as a fraction of the source population of inference:

$$P_m = 1 - \sum_{i=1}^{12} f_i \cdot (1 - PE_i \cdot P_S)^{duration} \qquad (8)$$

P_s was calculated as:

$$P_S = \frac{N_L}{N_T} \qquad (9)$$

where N_L represents the sampled source water population and N_T represents the local source population of inference. P_s has been defined by Ricker (1975), as the proportion of the parental stock. If the distribution in the larger area is assumed to be uniform, then the value of P_s for the proportion of the population will be the same as the value computed solely on area or volume.

Therefore, P_s was estimated using the distance the larvae could have traveled, based on the duration of exposure to entrainment and current speed, an analogue for volume. A current speed of 11.2 cm/sec was calculated from hourly measurements over the period of January 1, 1996 through May 31, 1999 at a single InterOceans S4™ current meter deployed at -6 m MLLW in approximately 30 m depth about 1 km west of the Diablo Canyon Power Plant Intake Cove south of Morro Bay. The current direction was ignored in the calculations, but is predominately alongshore. The current speed was used to estimate unidirectional displacement over the period of time that the larvae were exposed to entrainment. The value of alongshore displacement (N_T) was compared with the alongshore length of the sampled waterbody (N_L). A value of 9.6 km was used for N_L which is twice the distance of Station 5 to the west Morro Bay breakwater. This value was used because it places Station 5 in the center of the sampled waterbody. Based on an average exposure duration of 6.9 days for white croaker, P_s would be calculated as follows:

$$P_S = .14 = \frac{9.6km}{(6.9days)(9.7\,km^{days^{-1}})}$$

We only present a single estimate of P_m for white croaker and other taxa that used a P_s adjustment because any increase in P_m that may occur due to an extended larval duration is offset by the size of the population area due to the larger estimate of alongshore distance.

Table 2. *ETM* data and example calculations for white croaker *Genyonemus lineatus*.

Survey Date	Entrainment Estimate (#)	Entrainment Volume (m^3)	Morro Bay Estimate (#)	Morro Bay Volume (m3)	Morro Bay *PE*	Estero Bay Estimate (#)	Estero Bay Volume (m3)	Estero Bay *PE*	Total PE	f_i	Duration of Larval Exposure	$= f_i * (1-PE_i\ P_s)^{duration}$
17-Jan-00	0	1,619,190	0	15,686,663	0	0	20,915,551	0	0	0.0535	6.9	0.0535
28-Feb-00	0	1,619,190	19538	15,686,663	0	66482	20,915,551	0	0	0.3827	6.9	0.3827
27-Mar-00	46088	1,619,190	215626	15,686,663	0.2137	308637	20,915,551	0.1493	0.0879	0.0691	6.9	0.0634
24-Apr-00	2314	1,619,190	42942	15,686,663	0.0539	56458	20,915,551	0.0410	0.0233	0.1676	6.9	0.1639
15-May-00	0	1,619,190	0	15,686,663	0	0	20,915,551	0	0	0.0024	6.9	0.0024
12-Jun-00	0	1,619,190	0	15,686,663	0	0	20,915,551	0	0	0	6.9	0.0000
10-Jul-00	0	1,619,190	0	15,686,663	0	0	20,915,551	0	0	0.0064	6.9	0.0064
8-Aug-00	0	1,619,190	20998	15,686,663	0	111066	20,915,551	0	0	0	6.9	0.0000
5-Sep-00	2615	1,619,190	13287	15,686,663	0.1968	36110	20,915,551	0.0724	0.0529	0.0394	6.9	0.0374
2-Oct-00	2307	1,619,190	24605	15,686,663	0.0938	174301	20,915,551	0.0132	0.0116	0.005	6.9	0.0049
13-Nov-00	9748	1,619,190	101024	15,686,663	0.0965	51536	20,915,551	0.1891	0.0639	0.1584	6.9	0.1489
18-Dec-00	0	1,619,190	7625	15,686,663	0	31390	20,915,551	0	0	0.1156	6.9	0.1156

P_m Estimate $= 1 - \Sigma(f_i\ (1-PE_i\ P_s)^{duration}) =$ **0.0208**

2.2 Fecundity Hindcasting

An estimate of *FH* for white croaker was calculated using Equations 3 and 4, and the same approach described for combtooth blennies. White croaker spawn from 18 times per year for females of 1-2 years to 24 times for older females (Love et al. 1984). In our calculations for FH we used an average of 21 egg batches per year. A batch fecundity of 5,000 eggs was extrapolated from Love et al. (1984) resulting in a total annual fecundity of 105,000 eggs (*21 spawnings x 5,000 eggs*). Love (1996) reported that white croaker eggs hatch in about 2 days and Murdoch et al. (1989) suggested a daily instantaneous egg mortality rate of Z = 0.25 (survival=78 % per day). Egg survival was therefore estimated as $e^{(0.25*-2)} = 0.61$. The same instantaneous mortality rate was used to calculate larval survival from hatching to entrainment at 6.9 days based on the mean entrainment length ($e^{(0.25*-6.9)} = 0.18$). An estimate of longevity of 12 year from Love et al. (1984) was used in the model, and the average age of maturation was estimated to be 2 years based on Love's (1996) estimate that the species matures from 1 to 4 years with approximately half of the females spawning after one year. Using Equation 4 *FH* for white croaker was 53 adult females and was calculated as follows:

$$FH = 53 = \frac{2{,}992{,}510}{(0.6065)(.1775)(105{,}000)\dfrac{(12-2)}{2}}.$$

2.3 Adult Equivalent Loss

The calculation of *AEL*, illustrated in Appendix C of the Study Plan, requires survival estimates for the various life stages of white croaker from entrainment through recruitment as adults. No survival estimates for these life stages were available, therefore *AEL* was not calculated for white croaker.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix A
Cooling Water Intake Study Plan

Attachment 2

EXAMPLE *ETM* CALCULATION

June 26, 2001

Examples of ETM Calculations

This appendix presents data and example Empirical Transport Model (*ETM*) calculations for combtooth blennies (*Hypsoblennius* spp.) and KGB rockfish (*Sebastes* spp.). Combtooth blennies were chosen to represent taxa groups whose larvae are primarily distributed within the bay, while KGB rockfish represent taxa groups with distributions that may extend throughout the nearshore areas of Estero Bay. ETM estimates of P_m were calculated differently for these two groups of fishes.

The calculation of P_m for the two groups differed in whether the *PE* estimates for each survey applied to the entire local population or only a fraction of that population. The source water sampling was intended to provide a representative estimate of the population for taxa groups whose larve are distributed within the bay represented in this example by combtooth blennies. For these taxa the estimates of *PE* for each survey represent the conditional mortality for the entrainable life stage of the local population. Only a fraction of the local population was sampled by the source water sampling for fishes with broader coastwide distributions. For these taxa, their estimated *PE* only applied to the fraction of the local population that was subject to entrainment.

The calculation of P_m for the two groups differed in whether the *PE* estimates for each survey applied to the entire local population or only a fraction of that population. The source water sampling was intended to provide a representative estimate of the population for taxa groups whose larve are distributed within the bay represented in this example by combtooth blennies. For these taxa the estimates of *PE* for each survey represent the conditional mortality due to entrainment on the entire local population of interest. The source water sampling only included a fraction of the local population of fishes with broader nearshore distributions. Therefore the estimates of *PE* for these taxa only applied to the fraction of the local population that was subject to entrainment.

The *ETM* estimates of P_m for both taxa groups were calculated using proportional entrainment (*PE*) values from each source water survey. The value of PE_i estimates the daily conditional mortality due to entrainment. The value of 1- PE_i is an estimate of the daily conditional survivorship. The daily conditional survivorship is applied over the number of days that the larvae are in the plankton and subject to entrainment (i.e., $[1\text{-}PE_i]^{days}$). The number of days is estimated by dividing the maximum or average size of the entrained larvae by a daily growth rate. This value (i.e., $[1\text{-}PE_i]^{days}$) is an estimate of the proportion of the population surviving entrainment during the i^{th} survey period. The estimate of survivorship is weighted by the monthly survey fraction (f_i) of the source water population at risk. This value is the monthly fraction of total annual entrainment for the source water survey period. The weighted estimates of survivorship during each survey period are then summed and subtracted from unity to provide the final estimate of P_m using the formula:

$$P_m = 1 - \sum_{i=1}^{12} f_i \cdot (1 - PE_i)^{days}.$$

This formula was used for the majority of the taxa entrained by the MBPP that have larvae that are primarily distributed within the Morro Bay source water sampling area. For these taxa, P_m would estimate the probability of mortality due to entrainment for larvae within the source water sampling area.

Other fish taxa and many of the cancer crabs reside primarily in the nearshore, open-coast habitats found outside Morro Bay. Therefore, the *ETM* model was adjusted to include an estimate of the fraction of the local larval population sampled during the source water surveys. The following modified form of the *ETM* model was used for KGB rockfish and other fish and crab taxa with distributions that extend out into the nearshore waters where the source water sampling area represented only a fraction of the coastwide source waterbody:

$$P_m = 1 - \sum_{i=1}^{12} f_i \cdot (1 - PE_i \cdot P_S)^{days}$$

with P_s representing the proportion of the coastwide source waterbody represented in the sampling (Boreman et al. 1981, MacCall et al. 1983). P_s was calculated as

$$P_S = \frac{N_L}{N_T}$$

where N_L represents the sampled source water population and N_T represents the population of inference. Estimates of the population of inference for these taxa were unavailable.

P_s can also be estimated using the estimate of the larval or adult population in the study area, defined by Ricker (1975), as the proportion of the parental stock. If the distribution in the larger area is assumed to be uniform, then the value of P_s for the proportion of the population will be the same as the value computed based on area or volume. Therefore, P_s was estimated using the distance the larvae could have traveled based on the duration of exposure to entrainment and current speed. A current speed of 11.2 cm/sec (4.21 in./sec) was calculated from hourly measurements over the period of January 1, 1996 – May 31, 1999 at a single InterOceans S4^{TM} current meter deployed at -6 m (-19.8 ft) MLLW in approximately 30 m (99 ft) about 1 km

(0.6 mi) west of the Diablo Canyon Power Plant Intake Cove, south of Morro Bay. The current direction was ignored in the calculations, but was predominately alongshore. The current speed was used to estimate unidirectional displacement over the period of time that the larvae were exposed to entrainment. The value of alongshore displacement (N_T) was compared with the alongshore length of the sampled waterbody (N_L). A value of 6.0 mi (9.6 km) was used for N_L which is twice the distance of Station 5 to the west Morro Bay breakwater. This value was used because it places Station 5 in the center of the sampled waterbody.

Combtooth blennies

Data from the paired entrainment and source water surveys for combtooth blennies were used to calculate a *PE* estimate for each survey (Table ETM-1). Estimates of the mean density for the survey were obtained from the samples collected at the entrainment, bay and offshore stations. These estimates were multiplied by the volumes for those respective areas to obtain estimates of number of larvae. The estimate of *PE* for a survey was obtained by dividing the estimate of the number entrained by the combined estimate for the bay and offshore sampling areas. No estimate of *PE* was calculated for the February and April surveys because no larvae were collected in entrainment samples. An estimate of *PE* will be calculated for any survey where larvae are collected from entrainment because entrainment station samples are included in calculating a mean density for the bay source water area.

The *PE* estimates were combined with estimates of f_i and duration of entrainment risk to obtain an estimate of P_m. A growth rate for combtooth blenny larvae was estimated by averaging the growth rates of three sympatric blennioids (0.117, 0.19, 0.103 mm/day [0.005, 0.007, 0.004 in./day] from Stephens et al. (1970). This average growth rate was used to convert the mean length of 2.5 mm (0.098 in.) into an estimate of of approximately 4.0 days (Table ETM-2). As expected, the estimates of survivorship and f_i were equal for surveys where the *PE* estimate is zero. In other words, the entire fraction present during the survey period did not experience any entrainment related mortality. The estimates of survivorship for each survey were combined to provide a P_m estimate = 0.49.

KGB Rockfish

Data from the paired entrainment and source water surveys for KGB rockfishes were used to calculate a *PE* estimate for each survey (Table ETM-3). Estimates of the mean density for the survey were obtained from the samples collected at the entrainment, bay and offshore stations. These estimates were multiplied by the volumes for those respective areas to obtain estimates of number of larvae. The estimate of *PE* for a survey was obtained by dividing the estimate of the number entrained by the combined estimate for the bay and offshore sampling areas. No estimate of *PE* was calculated for the March and June surveys because no larvae were collected in entrainment samples.

The *PE* estimates were combined with estimates of f_i, duration of entrainment risk, and P_s to obtain an estimate of P_m. An estimate of the growth rate for KGB rockfish was not available from the literature, so a growth rate from larval brown rockfish of 0.14 mm/day (0.006 in.) (Love and Johnson 1999, Yoklavich et al. 1996) was used to estimate that the duration of entrainment risk for a mean length of 4.3 mm (0.17 in.) was approximately 5.5 days. This time period was used to compute an estimate of P_s according to the formula:

$$P_s = 0.179 \cong \frac{9.6km}{(5.5days \cdot 9.68km/day)},$$

where 9.6 km is the estimated alongshore extent of the source water sampling area, 5.5 days is the estimate of larval exposure to entrainment, and 9.68 km/day is the daily estimate of current displacement. The estimates of survivorship for each survey were combined to provide a P_m estimate = 0.02.

Table ETM-1. Values used in PE calculations for combtooth blennies *Hypsoblennius* spp.

Survey Date	Entrainment Mean Density	Entrainment Volume	Entrainment Estimate	Bay Density	Bay Volume	Bay Estimate	Bay PE	Offshore Density	Offshore Volume	Offshore Estimate	Offshore PE	Total PE
17-Jan-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
28-Feb-00	0.0000	1,619,190	0	0.0004	15,686,663	5,939	0.0000	0.0000	20,915,551	0	0.0000	0.0000
27-Mar-00	0.0050	1,619,190	8,027	0.0017	15,686,663	27,045	0.2968	0.0006	20,915,551	13,167	0.6097	0.1996
24-Apr-00	0.0000	1,619,190	0	0.0003	15,686,663	4,870	0.0000	0.0006	20,915,551	11,905	0.0000	0.0000
15-May-00	0.0019	1,619,190	3,077	0.0009	15,686,663	14,077	0.2186	0.0007	20,915,551	14,488	0.2124	0.1077
12-Jun-00	0.0066	1,619,190	10,700	0.0046	15,686,663	71,704	0.1492	0.0009	20,915,551	17,830	0.6001	0.1195
10-Jul-00	0.0537	1,619,190	86,893	0.0217	15,686,663	339,688	0.2558	0.0065	20,915,551	136,063	0.6386	0.1826
8-Aug-00	0.0979	1,619,190	158,591	0.0336	15,686,663	527,532	0.3006	0.0150	20,915,551	314,375	0.5045	0.1884
5-Sep-00	0.0585	1,619,190	94,659	0.0241	15,686,663	378,555	0.2501	0.0124	20,915,551	258,424	0.3663	0.1486
2-Oct-00	0.0117	1,619,190	18,889	0.0079	15,686,663	124,399	0.1518	0.0060	20,915,551	126,409	0.1494	0.0753
13-Nov-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
18-Dec-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000

Table ETM-2. Values used in calculating the P_m estimate for combtooth blennies.

Survey Date	PE_i	f_i	**Larval duration**	**Survivorship** $(f_i\,(1\text{-}PE_i)^{days})$
17-Jan-00	0.0000	0.0021	4.04	0.0021
28-Feb-00	0.0000	0.0069	4.04	0.0069
27-Mar-00	0.1996	0.0031	4.04	0.0013
24-Apr-00	0.0000	0.0023	4.04	0.0023
15-May-00	0.1077	0.0048	4.04	0.0030
12-Jun-00	0.1195	0.0266	4.04	0.0159
10-Jul-00	0.1826	0.2457	4.04	0.1088
8-Aug-00	0.1884	0.3702	4.04	0.1593
5-Sep-00	0.1486	0.2241	4.04	0.1170
2-Oct-00	0.0753	0.0832	4.04	0.0606
13-Nov-00	0.0000	0.0273	4.04	0.0273
18-Dec-00	0.0000	0.0038	4.04	0.0038
			P_m =	0.4913

Table ETM-3. Values used in PE calculations for KGB rockfishes *Sebastes* spp.

Survey Date	Entrainment Mean Density	Entrainment Volume	Entrainment Estimate	Bay Density	Bay Volume	Bay Estimate	Bay PE	Offshore Density	Offshore Volume	Offshore Estimate	Offshore PE	Total PE
17-Jan-00	0.0034	1,619,190	5,504	0.0011	15,686,663	17,775	0.3097	0.0000	20,915,551	0	0.0000	0.3097
28-Feb-00	0.0013	1,619,190	2,179	0.0013	15,686,663	20,714	0.1052	0.0011	20,915,551	22,065	0.0987	0.0509
27-Mar-00	0.0000	1,619,190	0	0.0004	15,686,663	6,551	0.0000	0.0089	20,915,551	185,943	0.0000	0.0000
24-Apr-00	0.0235	1,619,190	38,097	0.0456	15,686,663	714,886	0.0533	0.0275	20,915,551	576,010	0.0661	0.0295
15-May-00	0.0028	1,619,190	4,457	0.0008	15,686,663	11,775	0.3785	0.0097	20,915,551	202,337	0.0220	0.0208
12-Jun-00	0.0000	1,619,190	0	0.0009	15,686,663	14,878	0.0000	0.0007	20,915,551	15,418	0.0000	0.0000
10-Jul-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
8-Aug-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
5-Sep-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
2-Oct-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
13-Nov-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000
18-Dec-00	0.0000	1,619,190	0	0.0000	15,686,663	0	0.0000	0.0000	20,915,551	0	0.0000	0.0000

Table ETM-4. Values used in calculating the P_m estimate for KGB rockfishes.

Survey Date	PE_i	f_i	Larval duration	P_s	Survivorship $(f_i (1-PE_i P_s)^{days})$
17-Jan-00	0.3097	0.0040	5.55	0.179	0.0029
28-Feb-00	0.0509	0.0308	5.55	0.179	0.0293
27-Mar-00	0.0000	0.0849	5.55	0.179	0.0849
24-Apr-00	0.0295	0.6811	5.55	0.179	0.6614
15-May-00	0.0208	0.0847	5.55	0.179	0.0830
12-Jun-00	0.0000	0.1145	5.55	0.179	0.1145
10-Jul-00	0.0000	0.0000	5.55	0.179	0.0000
8-Aug-00	0.0000	0.0000	5.55	0.179	0.0000
5-Sep-00	0.0000	0.0000	5.55	0.179	0.0000
2-Oct-00	0.0000	0.0000	5.55	0.179	0.0000
13-Nov-00	0.0000	0.0000	5.55	0.179	0.0000
18-Dec-00	0.0000	0.0000	5.55	0.179	0.0000
				P_m =	0.0241

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Appendix B

Data comparing all fishes collected in various studies of Morro and Estero Bays

Table B-1. Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Spiny dogfish *Squalus acanthias*					X			
Swell shark *Cephaloscyllium ventriosum*				X	X			
Filetail cat shark *Parmaturus xaniurus*					X			
Pacific angel shark *Squatina californica*	X							
Leopard shark *Triakis semifasciata*	X			X	X	X		
Horn shark *Heterodontus francisci*	X			X				
Horn shark egg case *Heterodontus francisci*					X			
Gray smoothhound *Mustelus californicus*	X	X		X				
Thornback *Platyrhinoidis triseriata*	X			X	X	X		
Shovelnose guitarfish *Rhinobatos productus*	X			X	X			
Ratfish *Hydrolagus colliei*					X	X		
Round stingray *Urolophus halleri*	X			X	X			
Bat ray *Myliobatis californica*	X	X	X	X	X	X		
Electric ray *Torpedo californica*					X	X		
Big skate *Raja binoculata*	X			X				
Silversides, unidentified Atherinidae						X	X	X
Topsmelt *Atherinops affinis*	X	X	X	X	X	X	X	X

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Jacksmelt *Atherinopsis californiensis*	X	X	X	X	X	X	X	X
Smelts, unidentified Osmeridae						X	X	X
Night smelt *Sprinchus starski*				X		X		
Pacific argentine *Argentina sialis*							X	
Popeye blacksmelt *Bathylagus ochotensis*							X	X
California grunion *Leuresthes tenius*					X			
King-of-the-salmon *Trachipterus altivelis*					X		X	
Ribbon fishes, unidentified Trachipteridae							X	
Tubesnout *Aulorhynchus flavidus*				X	X	X	X	
Tube blennies, unidentified Chaenopsidae							X	X
Blennies, unidentified Blenniidae						X	X	
Hypsoblennies, unidentified *Hypsoblennius* spp.							X	X
Rockpool blenny *Hypsoblennius gilberti*				X		X		
Mussel blenny *Hypsoblennius jenkinsi*						X		
Spotted cuskeel *Chilara taylori*				X	X	X		
Basketweave cusk-eel *Ophidion scrippsae*						X		
Pacific hake *Merluccius productus*					X		X	
Clingfish, unidentified *Gobiesox* spp.						X	X	X

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Northern clingfish *Gobiesox maeandricus*					X	X		
Kelp clingfish *Rimicola muscarum*	X			X				
Plainfin midshipman *Porichthys notatus*	X			X	X	X		
Hatchetfishes, unidentified *Sternoptyx* spp.							X	
Lanternfishes, unidentified Myctophidae							X	X
Northern lampfish *Stenobrachuis leucopsarus*							X	X
California headlight fish *Diaphus theta*								X
Longfin lanternfish *Diogenichthys atlanticus*							X	
Blue lanternfish *Tarletonbeania crenularis*							X	X
Broadfin lampfish *Nannobrachium ritteri*							X	
Pinpoint lanternfish *Nannobrachium regalis*								X
Red brotula *Brosmophycis marginata*							X	
Sculpins, unidentified Cottidae						X	X	X
Sculpins, unidentified *Clinocottus* spp.						X		
Sculpins, unidentified *Radulinus* spp.								X
Sculpins, unidentified *Icelinus* spp.							X	
Sculpins, unidentified *Ruscarius* spp.							X	
Sculpins, unidentified *Oligocottus* spp.							X	X

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Sculpins, unidentified *Artedius* spp.						X	X	X
Smoothhead sculpin *Artedius lateralis*	X				X	X	X	X
Pacific staghorn sculpin *Leptocottus armatus*	X	X	X	X	X	X	X	X
Snubnose sculpin *Orthonopias triacis*					X	X	X	X
Wooly sculpin *Clinocottus analis*							X	X
Coralline sculpin *Artedius corallinus*					X			
Cabezon *Scorpaenichthys marmoratus*	X		X	X	X	X	X	X
Bonyhead sculpin *Artedius notospilotus*				X	X	X		
Tidepool sculpin *Oligocottus maculosus*							X	
Manacled sculpin *Synchirus gilli*						X		
Prickly sculpin *Cottus asper*	X						X	X
Riffle sculpin *Cottus gulosus*	X							
Fluffy sculpin *Oligocottus snyderi*						X		
Roughcheek sculpin *Artedius creaseri*					X		X	X
Snailfishes, unidentified *Liparis* spp.							X	X
Slipskin snailfish *Liparis fucensis*								X
Poachers, unidentified Agonidae			X	X		X	X	X
Pygmy poacher *Odontopyxis trispinosa*						X		X
Pricklebreast poacher *Stellerina xyosterna*				X	X	X		

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Kelp bass *Paralabrax clathratus*				X	X			
Barred sand bass *Paralabrax nebulifer*				X				
Grunts, unidentified Haemulidae							X	
Salema *Xenistius californiensis*								X
Croakers, unid. Sciaenidae							X	X
White croaker *Genyonemus lineatus*				X	X	X	X	X
Spotfin croaker *Roncador stearnsii*			X					
Queenfish *Seriphus politus*				X	X		X	
Northern anchovy *Engraulis mordax*	X	X		X	X	X	X	X
California lizardfish *Synodus lucioceps*				X	X			
Jack mackerel *Trachurus symmetricus*	X		X	X	X			
Pacific mackerel *Scomber japonica*						X		
Gunnels/pricklebacks, unidentified Pholididae/Stichaeididae						X		
Pricklebacks, unidentified Stichaeididae						X	X	X
Gunnels, unidentified Pholididae			X	X		X	X	X
Kelp gunnel *Ulvicola sanctaerosae*						X		
Penpoint gunnel *Apodichthys flavidus*	X			X	X	X		
Rockweed gunnel *Xererpes fucorum*	X			X	X	X		
Sand lance *Ammodytes hexapterus*					X		X	

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Clinid kelpfishes, unid. Clinidae							X	
Labrisomid kelpfishes, unid. Labrisomidae							X	X
Kelpfish, unid. *Gibbonsia* spp.				X		X	X	X
Crevice kelpfish *Gibbonsia montereyensis*	X					X		
Giant kelpfish *Heterostichus rostratus*	X			X	X	X		
Striped kelpfish *Gibbonsia metzi*				X	X	X		
Spotted kelpfish *Gibbonsia elegans*					X			
Fringeheads, unidentified *Neoclinus* spp.							X	
One spot fringehead *Neoclinus uninotatus*					X	X		
Sarcastic fringehead *Neoclinus blanchardi*				X	X			
Monkeyface prickleback *Cebidichthys violaceus*	X				X		X	X
Masked prickleback *Stichaeopsis* spp.					X			
Ribbon prickleback *Phytichthys chirus*						X		
Rock prickleback *Xiphister mucosus*						X		
Combfishes *Zaniolepis* spp.							X	
Shortspine combfish *Zaniolepis frenata*							X	
High cockscomb *Anoplarchus purpurescens*					X	X		
Greenlings, unidentified *Hexagrammidae*							X	X
Lingcod *Ophiodon elongatus*	X		X	X	X	X		

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Painted greenling *Oxylebius pictus*	X						X	X
Kelp greenling *Hexagrammos decagrammus*			X	X	X	X		
Pipefishes, unidentified *Syngnathus* spp.				X		X	X	X
Kelp pipefish *Syngnathus californiensis*	X					X		
Bay pipefish *Syngnathus leptorhynchus*	X	X		X	X	X	X	X
Snubnose pipefish *Syngnathus arctus*				X				
California needlefish *Strongylura exilis*			X					
Pacific sardine *Sardinops sagax*	X			X		X	X	X
Gobies, unidentified Gobiidae							X	X
Shadow goby *Quietula y-cauda*		X					X	X
Arrow goby *Clevelandia ios*	X	X		X			*	*
Longjaw mudsucker *Gillichthys mirabilis*	X					X	X	X
Blackeye goby *Coryphopterus nicholsi*							X	X
Blind goby *Typhlogobius californiensis*							X	X
Tidewater goby *Eucyclogobius newberryi*	X	0						
Bay goby *Lepidogobius lepidus*	X	X		X	X	X	X	X
Surfperches, unidentified Embiotocidae			X			X		
Walleye surfperch *Hyperprosopon argenteum*	X	X	X	X	X	X		
Shiner perch *Cymatogaster aggregata*	X	X	X	X	X	X		

*All of the larval specimens sent from the unidentified goby category were genetically identified as arrow goby.

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Silver surfperch *Hyperprosopon ellipticum*			X		X			
Kelp surfperch *Brachyistius frenatus*					X	X		
Barred surfperch *Amphistichus argenteus*			X			X		
Dwarf surfperch *Micrometrus minimus*	X	X	X	X	X			
Striped surfperch *Embiotoca lateralis*	X		X		X	X		
Rubberlip surfperch *Rhacochilus toxotes*	X		X	X	X			
Sharpnose seaperch *Phanerodon atripes*	X							
Reef surfperch *Micrometrus aurora*			X		X			
White surfperch *Phanerodon furcatus*	X		X	X	X	X		
Pile surfperch *Damalichthys vacca*	X	X	X	X	X	X		
Rainbow surfperch *Hypsurus caryi*	X			X	X	X		
Black surfperch *Embiotoca jacksoni*	X	X	X	X	X	X		
Spotfin surfperch *Hyperprosopon anale*			X	X	X	X		
Surfperch unidentified juvenile					X			
Ronquils, unidentified Bathymasteridae							X	X
Smooth ronquil *Rathbunella hypoplecta*					X			
Pacific tomcod *Gadus macrocephalus*				X		X		
Common mola *Mola mola*					X			
Sharksucker *Echeneis naucrates*						X		

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Herrings and anchovies, unid. Clupeiformes							X	
Herrings, unidentified Clupeidae								X
Pacific herring *Clupea pallasii*	X	X		X	X	X	X	X
Medusa fish *Icichthys lockingtoni*					X	X	X	X
Pacific butterfish *Peprilus simillimus*	X				X	X		
Lefteye flounders & sanddabs, unid. Paralichthyidae							X	X
Flatfishes, unidentified Pleuronectidae				X			X	X
Flatfishes, unidentified *Hypsopsetta* spp.							X	
Flatfishes, unidentified Pleuronectiformes							X	X
Turbots, unidentified *Pleuronichthys* spp.								X
Sanddabs, unidentified *Citharichthys* spp.						X	X	X
California tonguefish *Symphurus atricauda*	X			X	X	X		
Speckled sanddab *Citharichthys stigmaeus*	X	X	X	X	X	X	X	X
Pacific sanddab *Citharichthys sordidus*			X			X	X	X
Diamond turbot *Hypsosetta guttulata*	X	X	X	X	X			
Hornyhead turbot *Pleuronichthys verticalis*				X			X	X
C-O turbot *Pleuronichthys coenosus*	X			X	X	X		
Curlfin turbot *Pleuronichthys decurrens*			X	X	X	X		

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Spotted turbot *Pleuronichthys ritteri*	X			X				
Starry flounder *Platichthys stellatus*	X	X		X	X	X	X	X
California halibut *Paralichthys californicus*	X		X	X	X		X	X
Dover sole *Microstomus pacificus*						X		X
Slender sole *Eopsetta exilis*						X		
Sand sole *Psettichthys melanostictus*	X		X	X		X	X	X
Rock sole *Pleuronectes bilineatus*							X	X
English sole *Parophrys vetulus*	X		X	X	X	X	X	X
Rockfishes, unidentified *Sebastes* spp.		X		X		X	X	X
Rockfish unidentified juvenile *Sebastes* spp.					X	X		
Chilipepper *Sebastes goodei*						X		
Brown rockfish *Sebastes auriculatus*	X			X	X	X		
Black rockfish *Sebastes melanops*				X		X		
Calico rockfish *Sebastes dalli*	X							
Blue rockfish *Sebastes mystinus*	X				X			
Bocaccio *Sebastes paucispinus*	X			X	X	X		
Stripetail rockfish *Sebastes saxicola*				X				
Grass rockfish *Sebastes rastrelliger*	X			X	X	X		
Copper rockfish *Sebastes caurinus*					X	X		

Table B-1 (continued). Presence and absence data of all fishes collected in various studies in Morro and Estero Bays.

Species	Fierstine Studies 1968 – 1970 (Fierstine et al. 1973)	Horn Studies 1974 – 1976 (Horn 1980)	PG&E 1973 Beneficial Uses (PG&E 1973)	CDFG Otter Trawls Mar 1992 – Jul 1999 (CDFG unpubl. data)	PG&E 1977 – 1978 MBPP Impingement (Behrens and Sommerville 1982)	MBPP Impingement 1999 – 2000 (Tenera 2000)	MBPP Entrainment Jan – Dec 2000 (Tenera 2000)	MBPP Source Water Jan – Dec 2000 (Tenera 2000)
Widow rockfish *Sebastes entomelas*					X			
Black-and-yellow rockfish *Sebastes chrysomelas*					X	X		
Black-&-yellow/gopher rockfish *Sebastes chrysomelas/S. carnatus*						X		
Kelp rockfish *Sebastes atrovirens*					X	X		
Aurora rockfish *Sebastes aurora*							X	
Olive rockfish *Sebastes serranoides*	X				X	X		
Olive-Yellowtail rockfish juv. *Sebastes serranoides/flavidus*					X			
Gopher rockfish *Sebastes carnatus*				X	X	X		
Vermilion rockfish *Sebastes miniatus*				X				
Spotted scorpionfish *Scorpaena guttata*				X		X		
Thornyheads *Sebastolobus spp.*								X
Sablefish *Anoplopoma fimbria*					X			
Senorita *Oxyjulis californica*				X	X			
Steelhead *Salmo gairdneri*	X							
Killifish, unid. Cyprinodontidae				X				
California killifish *Fundulus parvispinnus*	X	X						
Mosquitofish *Gambusia affinis*	X							
Threespine stickleback *Gasterosteus aculeatus*	X							
Green sunfish *Lepomis cyanellus*	X							
Unidentified fish						X	X	X

Literature Cited

Behrens, D. W., D. C. Sommerville. 1982. Impingement studies at the Morro Bay Power Plant. Report 026.22-80.1. Pacific Gas and Electric Company, Dep. Eng. Res., San Ramon, CA.

California Department of Fish and Game (CDFG), Morro Bay Office, unpublished Moro Bay otter trawl data, 1992–1999.

Fierstine, H. L., K. F. Kline, G. R. Garman. 1973. Fishes collected in Morro Bay, California between January, 1968 and December, 1970. California Department of Fish and Game. 59(1): 73-78.

Horn, M. H. 1980. Diel and Seasonal Variation in Abundance and Diversity of Shallow Water Fish Populations in Morro Bay, California. California Fish and Game Bulletin. 78(3):759-770.

Pacific Gas & Electric (PG&E). 1973. Evaluation of the effect of cooling water discharges on the beneficial uses of receiving waters at Morro Bay Power Plant. PG&E, San Francisco.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix C

Calculation of a Morro Bay Tidal Exchange Ratio

and

Questions Regarding the Tidal Exchange Ratio

by

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Calculation of a Tidal Exchange Ratio

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Data and Calculations

The "Tidal Exchange Ratio" or *TER* is the fraction of the total tidal exchange that consists of "new" water coming into the estuary, i.e., water that did not leave the estuary on the previous tidal cycle. In Morro Bay, the "total tidal exchange" is the synonymous with the tidal prism. Depending on the context, one can use either the daily tidal prism (8,270 ac ft) or the total daily tidal exchange (12,560 ac. ft, reckoned as twice the volume between MLW and MHW). The ratio *TER* is difficult to estimate from measurements, because: a) the currents that prevail outside of any estuary mouth are complex and variable, and b) it is quite sensitive to processes inside the estuary, especially river inflow and density stratification.

A method has been devised, however, to measure this ratio from the properties of water flowing in and out of an estuary entrance. This approach is much less dependent on the vagaries of shelf currents, though this variability still affects the results achieved. The *TER* is defined for a positive estuary (Largier, 1996) as:

$$TER = \left(\frac{S_{in} - S_{out}}{S_{ocean} - S_{out}} \right) \tag{1}$$

where: S_{in} is the salinity of water coming into the estuary, S_{out} is the salinity of the water leaving the estuary, and S_{ocean} is the salinity of the ocean source water. *TER* varies from 0 to 1. If the same water goes in and out on flood and ebb, the result is 0 ($S_{in} = S_{out}$). If no "old" water comes back in that went out on ebb, $S_{ocean} = S_{in}$, and $TER = 1$.

S_{in} is measured as the salt transport into the estuary over the flood half of a 12.42 hr a tidal cycle (or during both floods of a 24.84 hr tidal day) divided by the landward water transport. S_{out} is calculated as the salt transport out of the estuary over the ebb half of a 12.42 hr a tidal cycle (or during both ebbs of a 24.84 hr tidal day) divided by the seaward water transport. S_{ocean} is the maximum salinity observed during the 12.42 or 24.84 hr period at an estuary mooring, or if a coastal mooring is located totally away from the estuary outflow, the average salinity value. *TER* can then be estimated from time series data at regular intervals; I used a 3-hr interval for the 12.42 hr estimate and 6-hr intervals for the tidal daily calculation. Ideally, these measurements should be made using several current meters located at the ends of the jetties. One meter outside the estuary could be used to estimate ocean salinity, if sufficient instrumentation were available.

The procedure implied by (1) sounds simple, but is complicated by the properties of the limited data available near the entrance, one 13-d S4 current meter record located near the seabed at the end of the sand spit, near marker #8. This record has 24 samples per hour, with both velocity and salinity collected at each time. Because this mooring is some distance from the entrance, much of the water measured at this mooring goes back and forth in the channel without actually ever leaving the estuary. This is especially true on the lesser ebb each day, when little salinity change is observed at the mooring, and on the neap tide. Also, near-bed data over-estimate the true cross-sectional average of S_{out} more than they overestimate the cross-sectional average of S_{in}, because there is more stratification on ebb than flood. Therefore, any estimate arrived at is highly conservative – data collected nearer to the mouth would give a higher *TER*, because less of the water that passed the meter would simply be that trapped in the channel without going to the ocean. Data collected throughout the water column (or at a meter closer to mid-depth) would give a higher *TER*, because they would more accurately reflect the decrease in salinity near the surface on ebb.

Having examined the data and calculated results, I believe that the better estimate is that based on the 12.84 hr tidal cycle. I've rejected the 24.84 hr estimate for this mooring, because too little of the water passing this mooring on the lesser ebb actually leaves the estuary, so no realistic answer can be achieved except on the greater ebb. In fact, the value of *TER* on the lesser ebb was sometimes <0, which is clearly not realistic. In order to focus on the realistic part of the output and reject results contaminated by the results for the lesser ebb, I have also plotted the maximum value in a 25-hr running window (Figure 1).

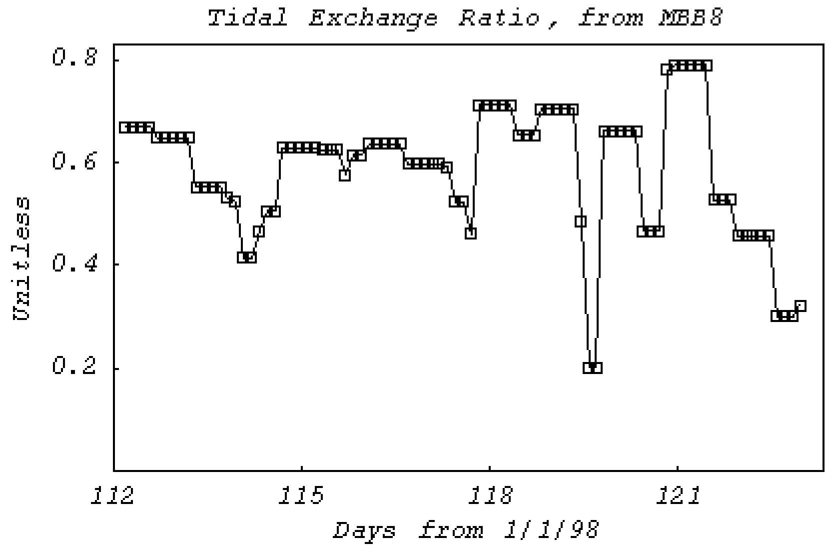

Figure 1: Tidal exchange ratio TER estimated from mooring MBB8; data from Tetra Tech; Tetra Tech (1999).

Figure 1 suggests that *TER* is 0.6-0.8 most of the time but drops to 0.2 to 0.4 sporadically, but especially on the neap. The apparent decrease in *TER* on the neap is likely not realistic – there is no inherent reason why *TER* should be lower on a neap. This decrease probably reflects the fact that the mooring is too far from the entrance to be useful during this period. Given the extremely conservative calculation implied by using a mooring that is well landward of the entrance and near the seabed, it is defendable to use a TER value near the upper end of the range seen in Figure 1, perhaps 0.7 to 0.8. Some seasonal variability will also likely occur, however. Reduced freshwater inflow could, for example, decrease *TER* by decreasing stratification and shear, unless there were compensating changes in the ocean. It is impossible to predict the variations in *TER* that would result from changing shelf circulation conditions, e.g., seasonal variations in the upwelling regime.

Summary and Conclusions

1. The "Tidal Exchange Ratio" or *TER* is the fraction of the total tidal exchange that consists of "new" water coming into the estuary, i.e., water that did not leave the estuary on the previous tidal cycle. In Morro bay, the "total tidal exchange" is the synonymous with the tidal prism. Depending on the context, one can use either the daily tidal prism (8,270 ac ft) or the total daily tidal exchange (12,560 ac. ft, reckoned as twice the volume between MLW and MHW).

2. Calculations from limited data suggest that a *TER* value of 0.7 to 0.8 is probably appropriate for Morro Bay, at least during the spring period for which data are available.

3. If a more definite value of *TER* is required, then it would be advisable to install current meters (with salinity) near the entrance of Morro Bay and on the shelf before the end of the winter. As the bay warms and salinities increase in early spring, it will be impossible to use the method of eq (1) to define *TER*, because salinity differences between bay and ocean water will become too small to allow an accurate calculation.

References

Largier, J., 1996, Hydrodynamic exchange between San Francisco Bay and the ocean: the role of ocean circulation and stratification, in: J. T. Hollibaugh (ed.), San Francisco Bay the Ecosystem, AAAS, San Francisco, pp. 69-104.

Tetra Tech, Inc., 1999, *Morro Bay National Estuary Program Hydrodynamic Circulation Model*, Lafeyette, CA., various paginations

Attachment to Appendix C

Questions Regarding the Tidal Exchange Ratio

by

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Questions Regarding the Tidal Exchange Ratio

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At the April 30, 2001 meeting of the Technical Working Group, a discussion was held in which the following questions were raised regarding the "Tidal Exchange Ratio," or *TER,* as described in Appendix A of the draft MBPP 316(b) Resource Assessment report:

1. How representative are the existing calculations of *TER* with respect to annual cycles of tidal range, estuarine circulation and coastal conditions?
2. Given that the *TER* was calculated in such a way that it reflects (in most cases) only one tide per day, should the value *TER* be reduced by a factor of two?
3. What is the best estimate of *TER*? Why did I suggest a value of *TER* = 0.7 to 0.8, instead of an arithmetic mean of the values?

The "Tidal Exchange Ratio" or *TER* is the fraction of the total tidal exchange that consists of "new" water coming into the estuary, i.e., water that did not leave the estuary on the previous tidal cycle. In Morro Bay, the "total tidal exchange" is the same as the tidal prism. Depending on the context, one can use either the daily tidal prism (8,270 ac ft) or the total daily tidal exchange (12,560 ac. ft, reckoned as twice the volume between MLW and MHW).

The *TER* is defined as follows (Largier, 1996):

$$TER = \left(\frac{S_{in} - S_{out}}{S_{ocean} - S_{out}} \right) \tag{1}$$

where: S_{in} is the salinity of water coming into the estuary, S_{out} is the salinity of the water leaving the estuary, and S_{ocean} is the salinity of the ocean source water. *TER* varies from 0 to 1. If the same water goes in and out on flood and ebb, the result is 0 ($S_{in} = S_{out}$). If no "old" water comes back in that went out on ebb, $S_{ocean} = S_{in}$, and $TER = 1$. S_{in} is measured as the salt transport into the estuary over the flood half of a 12.42 hr tidal cycle (or during both floods of a 24.84 hr tidal day) divided by the landward water transport. S_{out} is calculated as the salt transport out of the estuary over the ebb half of a 12.42 hr a tidal cycle divided by the seaward water transport. S_{ocean} is the maximum salinity observed during the 12.42 hr period at an estuary mooring, or if a coastal mooring is located totally away from the estuary outflow, the average salinity value. *TER* can then be estimated from time series data at regular intervals; I used a 3-hr interval. In order to focus on the realistic part of the output and reject results affected by the results for the lesser flood and ebb, I have also plotted the maximum value in a 25-hr running window (Figure 1). The lesser ebb flood and ebb data are deemed not to be representative, because the current meter was more than 1 km from the estuary entrance, a substantial fraction of the tidal excursion[1] on most lesser tides. While tidal excursion values varied from <3 km (weakest neap tide) to ~12.5 km, many lesser floods and ebbs had tidal excursions of <5-6 km. Under these circumstances, the distance between the meter and the entrance can be expected to have a major effect on the results.

Responses to the questions defined above:

[1] The tidal excursion is the distance that a parcel of water travels on a flood or ebb.

1. How representative are the results in Figure 1? There are issues with regard to: a) tidal variability, b) the high variability of estuary-coastal exchange, c) measurement of *TER*, and d) the instrument location. The data used to calculate *TER* were collected by Tetra Tech at the end of the sand spit near Marker #8, during the period 4/22/98 to 5/9/98 (Figure 2; Tetra Tech, 1999). The S4 current meter (with temperature and conductivity sensors) was located about 1 m (3 ft) above the bed. Reflecting this collection location (near the bed and on the inside of a sharp bend in the channel), currents were flood-dominant. Maximum flood currents were ~0.9 ms^{-1} (2.9 fts^{-1}), while maximum ebb currents were only ~0.7 ms^{-1} (2.3 fts^{-1}). The time period during which data were collected included a strong spring tide (4/26/98 to 4/27/98) and a weak neap tide (5/3/98 to 5/4/98). The greater diurnal tidal range during this period varied from 3.7 to 7.7 ft. (about 1.1 to 2.4 m), relative to the average diurnal range of 5.4 ft (1.7 m). While a period of less than a month does not encompass the full annual cycle of tidal processes, the data are certainly representative of the range of tidal conditions that would occur over the annual cycle. Also, tidal variability may not be the dominant factor, as there is not a clear neap-spring cycle in the calculated *TER*. *TER* has an intermediate value on the spring tide (~d 115), and high and low extremes occur between the spring and the neap. Neap values at the end of the record are quite low, but not the lowest in the record.

   How representative these *TER* results are relative to the annual cycles of freshwater inflow and coastal circulation is a more difficult question. Factors that would likely affect *TER* include freshwater inflow, stratification, winds, and coastal circulation. Strong coastal currents (to either the north or south) should remove from the vicinity of the jetties water leaving the estuary on ebb, increasing *TER*. Very strong freshwater flow might result in greater exchange, with *TER* approaching unity, but freshwater flow was low to moderate during the data collection period. The late-summer period of very weak stratification and freshwater inflow might show weaker tidal exchange than the spring (decreasing *TER*), given constant oceanic conditions. On the other hand, coastal circulation factors during the summer and fall might actually improve tidal exchange, increasing *TER*. Factors favoring strong exchange would likely include a strong sea breeze and coastal surface currents to the south. The latter is expected to be a factor, because of the orientation of the jetties.

   Characteristics of the density field are also important in measuring *TER*. *TER* is determined using the salinity difference between the bay and coastal ocean. As (S_{ocean} - S_{out}) approaches zero during the summer, the calculated *TER* ceases to have any statistical significance. An indeterminant *TER* does not mean that tidal exchange is weak, only that it cannot be measured from salinity differences. It is possible that it could be measured from temperature differences, but the daily cycle of atmospheric heating and cooling might render this calculation inaccurate. Thus, estimates of *TER* should be made based on data collected after the onset of winter rains and before (S_{ocean} - S_{out}) approaches zero in summer. The data set employed is appropriate in this regard.

   Finally, instrument position is important in two respects. *An instrument located some distance inside the estuary underestimates* S_{in} *and over-estimates* S_{out}*, leading to a very conservative evaluation of* (S_{in} - S_{out}) *and TER. TER calculated from a meter near the bed is also conservative because of systematic tidal changes in stratification and the vertical distribution of the tidal flow.* That is, near-bed data give a good estimate of S_{ocean}, but over-estimate the true cross-sectional average of S_{out} more than they overestimate the cross-sectional average of S_{in}. This occurs because there is usually more stratification and velocity shear on ebb than flood. The conservative bias imparted by the location employed in this study may outweigh the seasonal fluctuations that have not been accounted for.

   In summary, the calculated *TER* is reasonably representative of the annual cycle of tidal conditions. It is unclear how representative the results are with regard to seasonal fluctuations of freshwater flow and coastal circulation processes. However, the data employed were collected >1 km inside the estuary and near the bed. *This instrument location imparts a very conservative bias to the calculation, underestimating TER and the actual tidal exchange.*

2. Should the calculated *TER* be reduced by a factor of two? The answer here is simple. By definition, *TER* is the factor that is multiplied by the mean or greater daily tidal prism, to determine the amount of new water coming into the estuary on each tide or over a tidal day. The fact that the data do not allow the value of *TER* to be measured twice a day does not change the definition of *TER*, or the way that it is used. Thus, the answer is “no”.

3. What is the best estimate of *TER*? *The answer to question 1) indicates that the collection location of the current meter data make the calculated TER value very conservative.* In my best professional judgement, therefore, I suggested a value above the mean of 0.6 as the best estimate.

References

Largier, J., 1996, Hydrodynamic exchange between San Francisco Bay and the ocean: the role of ocean circulation and stratification, in: J. T. Hollibaugh (ed.), San Francisco Bay the Ecosystem, AAAS, San Francisco, pp. 69-104.

Tetra Tech, Inc., 1999, *Morro Bay National Estuary Program Hydrodynamic Circulation Model*, Lafayette, CA., various paginations.

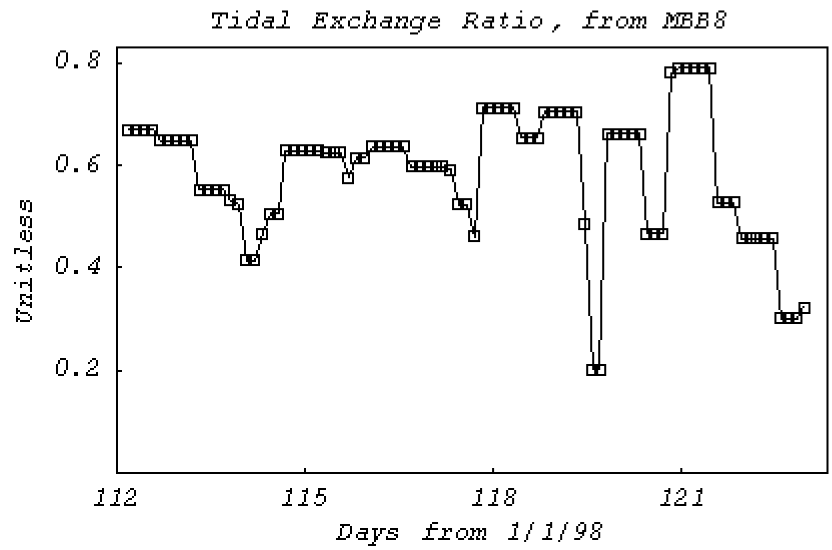

Figure 1: Tidal exchange ratio TER estimated from mooring MBB8; data from Tetra Tech (1999).

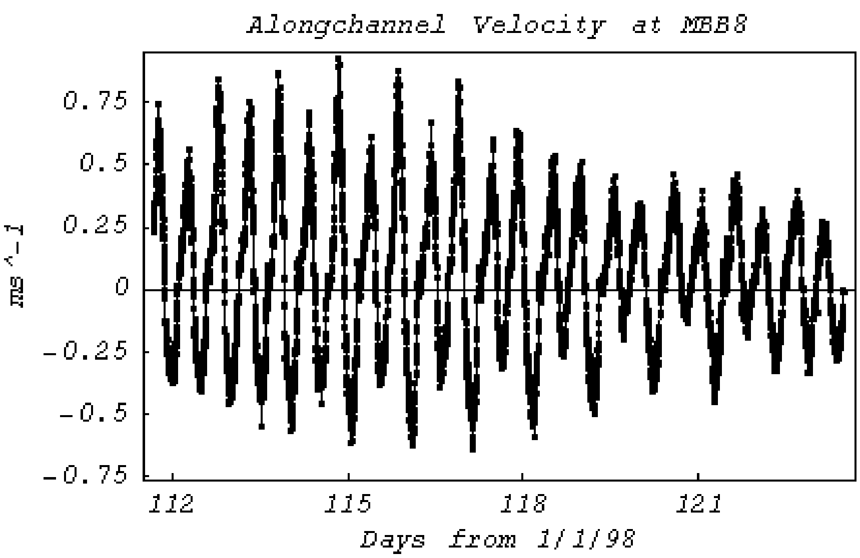

Figure 2: Hourly observed alongchannel velocity ~3 ft above the bed at MBB8; data from Tetra Tech (1999).

Morro Bay Power Plant Modernization Project
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Appendix D

Molecular identification and quantification of clam larvae in Morro Bay

by

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MOLECULAR IDENTIFICATION AND QUANTIFICATION OF CLAM LARVAE IN MORRO BAY

Jonathan Geller
Associate Professor
Moss Landing Marine Laboratories

Background and Synopsis: This document incorporates suggestions made at the December 4, 2000 and January 19, 2001 meetings of the Morro Bay Power Plant Technical Working Group at the Moss Landing Marine Laboratories, and recommendations suggested by Dr. Peter Raimondi on January 25, 2001. These discussions have helped to focus attention on objectives that will contribute to decision making related to Duke Energy's proposed modifications to the Morro Bay Power Plant.

This revised proposal 1) has an accelerated time-line, 2) uses fluorescent detection of species-specific molecular probes in individually sorted bivalve larvae, and 3) analyzes plankton samples to be collected in Morro Bay from March 2001-September 2001, a time period which brackets the major spawning season of most benthic invertebrates, and 4) implements an adaptive sampling strategy to capture pulses of bivalve recruitment. I will use existing sequence detection methods (exonuclease cleavage of reporter dyes from specific probes, also known as Taqman® assay). The targeted species are major prey items for sea otters: the Washington Clam, *Saxidomus nuttali,* Gaper clam, *Tresus nutalli* and Pismo clam, *Tivela stultorum*. Two other species, *Macoma secta* and *Mytilus galloprovincialis* are also otter prey, are likely to be particularly abundant in samples and are also targeted. A strategy for identifying and enumerating larvae which are not among these targeted species but turn out to be abundant in our samples is also proposed.

Sampling sites and schedule will be as performed earlier for ichthyoplankton work, except a weekly sample will be taken to detect the onset of recruitment pulses. Larval density data, in conjunction with plankton sample, entrainment and source water volume estimates, will be used by Tenera to estimate proportional losses due to entrainment for these clam species during the sampling period. This will be done in much the same way as it was done for fish to produce a parallel report.

Status Report (4-18-01). The project was funded 3-15-01. We have collected and determined DNA sequences from *Tresus nuttallii*, *Mytilus galloprovincialis*, three species of *Macoma*, *Protothaca staminea*, and *Clinocardium nuttallii*. We have additionally isolated tissues from *Tivela, Panopea*, and *Saxidomus*. One round of plankton sampling took place in March 2001. Bivalves sorted from one of five stations yielded 91 larvae, thus concern over possible null samples appears to be diminished. Initital Taqman probes are currently being designed and tested with *M. galloprovincialis.*

Introduction.

The key impediment to identification of clam larvae (as well as most other invertebrate and many fish larvae), is the lack of characterized diagnostic morphological features (Loosanoff et al. 1966, Chanley and Andrews 1971). While scanning electron microscopy can identify characteristics of the larval shell which allow sorting of larvae to species (Lutz and Jabonksi 1979, Lutz et al. 1982, Mullineaux et al. 1996), this is an impractical approach for routine analysis of plankton. In contrast, molecular methods allow for higher precision and faster throughput in identification (Geller 1997). Identification is unequivocal because adult organisms, which are unambiguously identified, can be used to determine DNA sequences which are specific to each species. DNA sequences, unlike morphology, are not dependent on the life stage of an organism, thus such diagnostic DNA sequences can be detected in a larva. A variety of molecular detection methods are available and have been used in zooplankton identification in past studies (Hare et al. 1994, Bucklin et al. 1998, Makinster et al. 1999, Hare et. al. 2000), and all recent molecular methods utilize the polymerase chain reaction (PCR). PCR is the amplification of a target sequence of DNA from a small quantity of starting DNA, such as could be extracted from an individual larva. The product of PCR is a large amount of a specific DNA fragment which can contain a diagnostic sequence.

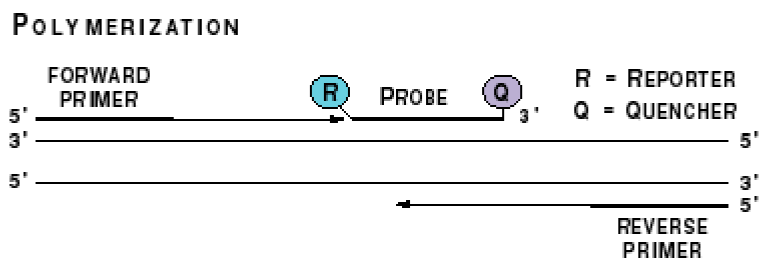
Until very recently, species-specific DNA sequences in PCR products were detected using post-PCR methods of analysis, such as DNA sequencing, restriction digestion, gel-electrophoresis or blot-hybridization. Post-PCR handling greatly increases time and labor, and reduces throughput. For example, Medeiros-Bergen (1995) identified sea cucumber larvae by using a species specific probe that bound to amplified larval DNA affixed in spots to nylon membranes (requiring 2-3 days per assay). More recently, Hare et al. (2000) used species-specific amplification primers to determine the identity of bivalve larvae. While this later approach significantly reduced the amount of post-PCR processing, it required gel electrophoresis of PCR products which roughly doubled the time required per set of samples. Thus, Hare et al. (2000) processed only 142 larvae, which would be insufficient for our purposes.

Newer technology (Real-Time PCR) allows the use of species-specific hybridization probes during PCR, eliminating all post-PCR processing. While rapidly growing in use in the biomedical fields, instrument costs have slowed the use of this technology in marine biology. Fortunately, MLML possesses the essential optical equipment. With our instrument (BioRad iCycler Q system) Real Time PCR allows up to 96 larvae to be analyzed with up to four species-specific probes in about 2 hours. A variety of probes and hybridization strategies can be used in Real Time PCR. We will use the most well developed technology called Taqman® assays.

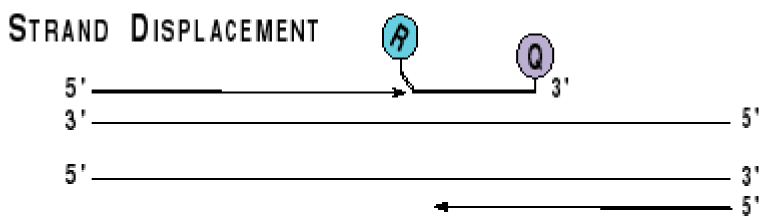
Taqman® technology. This process was developed by Applied Biosystems, Incorporated, and refers to the production of a fluorescent signal specific to particular DNA sequences (i.e., bivalve DNA sequences) and is illustrated in Figure 1. A species-specific probe is designed based upon sequences derived from identified adults. The probe is constructed with a reporter dye attached to one end (5') and a quencher dye attached to the other end (3'). The reaction is illuminated with light at a wavelength that induces excitation fluorescence in the reporter dye. An optical instrument reads the intensity of emitted fluorescence. However, the quencher dye absorbs this energy and re-emits it at a wavelength which is not detected. Thus, when the probe first binds to its corresponding target, no signal is produced. However, during PCR, a newly synthesizing DNA strand will displace the 5' end of the probe, exposing it to exonuclease digestion (Taq DNA polymerase used in PCR has both polymerase and exonuclease activity). Exonuclease digestion thus cleaves the reported dye from the probe, separating it from the quencher dye, and a fluorescent signal is produced. Newly synthesized PCR products become targets for detection in subsequent rounds of amplification/detection, greatly enhancing the fluorescent signal.

Figure 1. Taqman sequence detection system: R=reporter fluorophore, Q= quencher fluorophore.

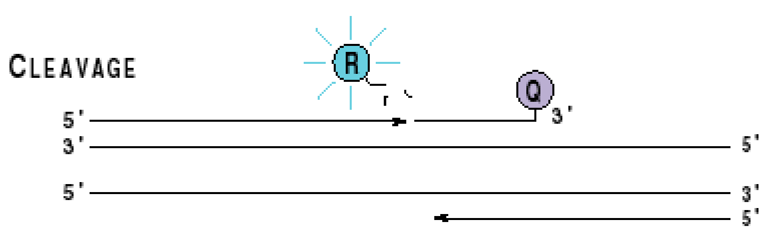
A. In solution, the reporter dye on the probe does not fluoresce due to the physical proximity of the quencher dye. During PCR, the probe anneals in a species-specific manner to single stranded DNA. Later, amplification primers anneal and Taq DNA polymerase begins to copy template DNA strands.



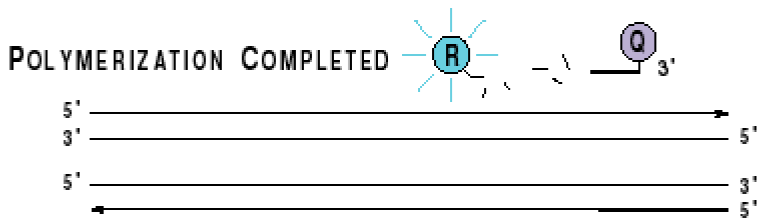
B. As the newly synthesizing strand contacts the annealed probe, the 5' end of the probe is displaced, exposing it to exonuclease digestion by Taq polymerase.



C. Exonuclease activity causes the reporter dye to be cleaved from the probe, releasing it into solution. Now, the reporter fluoresces and is detected by the optical instrument. Since one dye is released for each DNA copy, fluoresence is proportional to the amount of amplification product. In the absence of amplification, no fluorescent signal is produced.



D. A cycle of synthesis is complete, and newly synthesized products become template in further rounds of probe annealing. Because of amplification of template sequences, Taqman detection is very sensitive.



Methods.

The proposed project has five phases: 1) characterization of adult DNA sequences for probe design; 2) plankton sampling and sorting; 3) Taqman® detection of species specific DNA in larvae; 4) retroactive identification of abundant but still unidentified larvae; and 5) data analysis.

Phase 1. Adult Sequences from Targeted Species.

Three species, as major prey of sea otters, are initially selected for probe development. These are the Washington clam, *Saxidomus nuttali*, the Gaper clam, *Tresus nutalli,* and the Pismo clam, *Tivela stultorum*. Two additional species that are also prey and expected to be numerically dominant are *Mytilus galloprovincialis* and *Macoma secta*. Omission of these later two would likely lead to large numbers of unidentified larvae.

In addition to these primary targets, sequences from other abundant shallow water bivalves will be obtained to assist in phase 4, the retroactive identification of abundant larvae not belonging to the targeted species. Collections in Morro Bay and Elkhorn Slough will provide adults of these additional species. In all cases, sequences will be derived using standard methods to create a locally relevant sequence database. Tissue and shell vouchers of all adult specimens will be kept.

Phase 2. Plankton Sampling.

Most broadcast spawning bivalve species have peak spawning seasons in the spring and summer. We will sample at least monthly from March-September 2001. Samples will consist of five replicate vertical tows at the five stations previously used in Morro Bay surveys by Tenera. Samples will be collected using a 0.5 meter diameter, 100 um mesh size net. This mesh size will capture all later-staged shelled pediveligers. An attached flow meter will be used to estimate the volume of water sampled. Depth of bottom for each tow will be recorded. On each sampling date, collections will be made at four time points: Slack Higher High, Lower Low, Lower High, Higher Low tides.

Adaptive sampling strategy: Because spawning and recruitment of invertebrate larvae often occur as as short and punctuated events, a weekly plankton tow will be made at high tide at the station located at the powerplant intake. This single sample will be visually inspected under a dissecting scope to qualitatively assess larval bivalve abundances, and then archived. A high abundance of larvae will trigger weekly, full scale sampling until larval abundances decline. Thus, sampling will be minimally monthly, but may be weekly during periods of high larval abundance. Application of molecular assays to samples will be minimally monthly, but may be targeted to samples obtained during recruitment pulses. The Technical Advisory Panel will be consulted before making a decision to reduce sampling. If significantly greater sampling or molecular assays are recommended by the Technical Advisory Panel, the project budget may require augmentation.

Following existing protocols for oyster larvae (D. Hedgecock, Bodega Marine Laboratory, pers. com., and demonstrated to be successful in our laboratory with polychaete larvae and copepods), plankton will be concentrated to 1 liter, killed with 10 ml of chlorox, rinsed immediately in seawater, and preserved in 75% ethanol. Three replicate tows will be further analyzed, two will be archived.

Samples will examined for a rough estimate of bivalve larvae abundance. Samples will then be split using a plankton splitter until bivalve abundance is approximately 100 per subsample. Bivalve larvae will then be sorted and counted. In tows containing fewer than 100 larvae, all larvae will be counted and analyzed (such analyses will reveal only most abundant species-see below). Total abundance in plankton samples will be extrapolated, and total density in the water column estimated by dividing by the volume of water filtered. Ninety-one randomly chosen larvae will be distributed into 96-well microtiter plates containing 50 ul PCR buffer compatible with proteinase-K and frozen until analyzed (5 wells are left empty for control templates).

How many larvae should be assayed? The answer depends on how much importance is placed on detecting rare species (Figure 2). For example, to achieve detection in 95% of samples (tows) of a species that is 3 %, 2%, 1%, or 0.5% of all larvae, 100, 150, 300, or 600 larvae, respectively, would need to be processed. This roughly corresponds to 1,2,3,or 6 microtiter dishes. For practical purposes, a single microtiter dishes (91 larvae) may be a limit imposed by the time involved in plankton sorting.. If so, detection sensitivity would be 93.5%, 84%, 60%, and 36% for larvae as rare as 3%, 2%, 1%, and 0.5%, respectively. In a three tow set, however, detection would be 99.9%, 99.6%, 93.6%, and 74.5%, respectively. Thus, very rare (<0.5%) larvae might be often missed, but larvae as rare as 1-3% will almost always be detected.

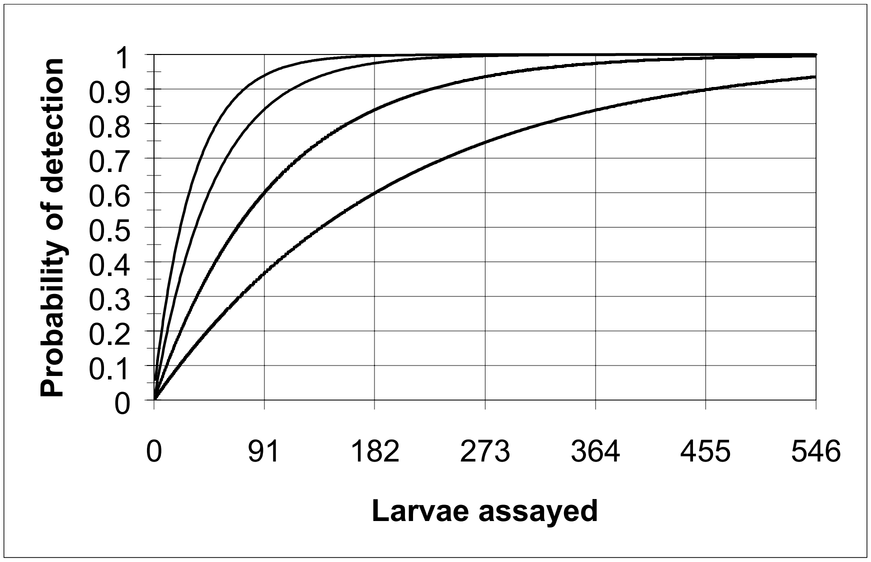


Figure 2. Probability of detection in one plankton sample, assuming target species is 3%, 2%, 1%, and 0.5% (lines from left to right) of total bivalve larvae. The x axis is labeled so as to correspond to microtiter dishes (96 wells minus 5 wells for controls=91 larvae).

The total sampling program consists of 5 tows x 5 stations x 4 time points x 6 months = 600 plankton samples Analysis will be based on three of each set of five tows = 360 samples x 91 larvae/microtiter plates =32,400 larvae.

Phase 3. Molecular analysis.

A. DNA extractions will follow a protocol used for oyster larvae from the genetics lab at the Bodega Marine Laboratory (D. Hedgecock, pers. com.). One µl of Proteinase-K (5 mg/ml) will be added to each well and incubated at 55^o C for 1 hour. Proteinase-K is then inactivated by raising the temperature to 95^o C for 10 minutes. Microtiter dishes are then centrifuged to collect any condensation. If further purification is needed, powdered silica, to which DNA binds in appropriate buffer conditions, will be added to samples, followed by washing away of impurities, resuspsion, centrifugation, and elution of DNA into Tris-EDTA.

B. Polymerase Chain Reaction. Amplification primers, deoxynucleotide triphosphate (dATP, dCTP, dGTP, and dTTP), Taq DNA polymerase, and four Taqman probes will be added to each well. Concentrations of probes, primers, dNTPs and $MgCl_2$ will need to be optimized in preliminary trials. PCR will be performed in the BioRad iCycler Q system. Each plate will contain a positive control for each species, and a negative control (no template). Ethidium bromide, which binds to double stranded DNA (dsDNA) and fluoresces at 595 nm is added to every reaction to detect production of dsDNA (as a check for amplification success).

Because only four species can be simultaneously monitored, while TWG wishes five species be studied, detection of *Tivela* will proceed in a different manner. An aliquot of PCR product from each plate will be pooled , diluted, and used a single template for a second Taqman assay using a *Tivela* probe. This approach will determine if any Tivela were present or absent in the original assay plate without incurring significant additional cost. If *Tivela* are detected, the *Tivela* probe will be added to the original assay plate to identify which larvae among those remaining unidentified were *Tivela*. In the event that Tivela is routinely detected, it can be substituted for a less often detected species among the first four targeted species. The displaced species will then be subject to presence/absence analysis as described above.

C. Primer and probe design. Past studies have shown high variability of mitochondrial cytochrome oxidase subunit I (CO I) in bivalves and a large database (472 sequences) exists in the EMBL and Genbank databases, thus this locus will be targeted. Previously published CO I primers (Folmer et al. 1995) that are effective for bivalves will be used to amplify this locus from adults of each targeted species and all geographically co-occurring congeners. Sixteen adults of each species from Morro Bay and Elkhorn Slough will be sampled and sequenced (using standard methods of PCR, cloning, and dideoxy-chain termination sequencing reactions) to assess any intraspecific variation that to be avoided in probe design. Probes will be designed according to ABI guidelines: to anneal to species-specific sequences, to lack secondary structures above melting temperatures that would inhibit annealing to templates, and to lack G at the 5' end. New PCR primers will be designed to bracket probe regions, minimize PCR product length. and to have melting temperatures 8-10^{o} C lower than probes. Probes will be tested on adult DNAs collected in Part 1.

Probes will utilize the following reporter-quencher combinations (see section above on *Tivela*):

Probe	5' Reporter	3' Quencher
Saxidomus	HEX	DABCYL
Tresus	FAM	DABCYL
Mytilus	Cy5	Black Hole 3
Macoma	Texas Red	Black Hole 2
Tivela	FAM	DABCYL

Phase 4. Unidentified but abundant larvae. A possible result is that some plankton samples may contain many larvae that give a positive amplification signal but are not identified by our probes. From such samples, sixteen PCR products will be randomly chosen, cloned and sequenced. These sequences will indicate whether unidentified larvae are a diverse pool of species or dominated by few. Comparison of sequences to our database of local species may identify many larvae. Minimally, we expect that comparison of sequences to our database and to the large number of bivalve CO I sequences in EMBL and Genbank will narrow the identification to a family or

genus, and referral to local species lists (Coan et al. 2000) should further narrow possible choices to a relatively few species.

If 1-3 species appear to dominate the pool of larvae that remain unidentified after a first round of probing, it would be straightforward to quantify their abundance in a second round of probing. New Taqman probes will be designed based on sequences of the abundant species discovered in phase 3. PCR products generated in the phase 3 will be used as templates (when diluted) for this second set of Taqman probes.

Phase 5. Data analysis. Geller will provide estimates of mean larval abundance (and variance) for each targeted species for each station and sampling period. Tenera will use these data to represent sourcewaters and entrained waters for calculations of proportional mortality attibutable to seawater uptake, as in models for fish larvae entrainment. A preliminary report of these results covering March-July 2001 will be prepared for August regulatory decision making, with a final report on the entire sample period in November 2001.

Literature Cited

Bucklin, A; Benthley, AM; Franzen, SP 1998. Distribution and relative abundance of *Pseudocalanus moultoni* and *P. newmani* (Copepoda: Calanoida) on Georges Bank using molecular identification of sibling species. Marine Biology 132: 97-106.

Coan, E.V., Scott, PV., and Bernard, F.R. 2000. Bivalve seashells of western North America. Marine Bivalve Mollusks from Arctic Alaska to Baja California. Santa Barbara Museum of Natural History.

Folmer, O; Black, M; Hoeh, W; Lutz, R; Vrijenhoek, R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294-299.

Geller, J.B. 1998 Molecular studies of marine invertebrate biodiversity: status and prospects. Chapter 18 in Cooksey, K.E. (ed). *Molecular Studies of the Sea*. Chapman, London.

Hare, JA; Cowen, RK; Zehr, JP; Jeanes, F; Day, KH 1994. Biological and oceanographic insights from larval labrid (Pisces: Labridae) identification using mtDNA sequences. Marine Biology 118: 17-24.

Hare, M.A., Palumbi, S.R., and Butman, C.A. 2000. Single-step species identification of bivalve larvae using multiplex polymerase chain reaction. Marine Biology 137:953-961.

Loosanoff, V.L., Davis, H.C., and Chanley, P.E. 1966. Dimensions and shapes of larvae of some marine bivalve mollusks. Malacalogia 4:351-435.

Lutz, R; Goodsell, J; Castagna, M; Chapman, S; Newell, C; Hidu, H; Mann, R; Jablonski, D; Kennedy, V; et al. 1982. Preliminary observations on the usefulness of hinge structures for identification of bivalve larvae. J. Shellfish Research 2: 65-70

Lutz, R.A.; Jablonski, D. 1979. Micro- and ultramorphology of larval bivalve shells: ecological, paleoecological, and paleoclimatic applications. Proc. Natl. Shellfish. Assoc 69: 197-198.

MaKinster, JG; Roberts, JE; Felder, DL; Chlan, CA; Boudreaux, M; Bilodeau, AL; Neigel, JE. 1999. PCR amplification of a middle repetitive element detects larval stone crabs (Crustacea: Decapoda: Menippidae) in estuarine plankton samples. Marine Ecology Progress Series 188: 161-168

Medeiros-Bergen, DE; Olson, RR; Conroy, JA; Kocher, TD 1995. Distribution of holothurian larvae determined with species-specific genetic probes. Limnology and Oceanography 40: 1225-1235.

Mullineaux, LS; Kim, SL; Pooley, A; Lutz, RA . 1996. Identification of archaeogastropod larvae from a hydrothermal vent community. Marine Biology 124: 551-560.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix E

Calculation of a Morro Bay Source Water Volume

by

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The Morro Bay Power Plant and Circulation Processes in Morro Bay

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15 March 2001

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1. **Executive Summary**

The Morro Bay Power Plant (MBPP) is located near the entrance to Morro Bay. The plant takes in cooling water from Morro Bay and discharges the heated effluent to the ocean outside of the bay. The volume of the intake flow depends on the level of plant operation. The minimum discharge is zero. The maximum discharge is 668 million gallons per day (MGD), equivalent to ~1,000 cubic feet per second (cfs). When the MBPP is operating, the intake flow creates a steady current near the entrance of the bay. This mean flow moves in a landward direction from the mouth of the bay toward the plant. Landward of the plant this current does not exist. There are also two tributary streams to the bay that affect current patterns in the bay, Chorro and Los Osos Creeks. Flows in these streams vary from a few cfs to >1,560 cfs (the two-year flood level). These creeks enter the middle of Morro Bay on its east side and create, therefore, a mean flow[1] from the land to the ocean that extends from mid-bay to the ocean.

The possible impacts of the MBPP intake flow on tidal processes in Morro Bay have arisen as an issue in the Application for Certification process. The concern is that the MBPP intake flow decreases the tidal prism of the bay or in some other way affects tidal processes and long-term shoaling patterns. This report describes analyses that evaluate the validity of this concern. To insure a rigorous and decisive result, the analyses are posed in terms of formal hypotheses, and state-of-the-art tidal analysis methods are used for hypothesis tests. The focus is on tidal processes (instead of transport *per se*) because: a) tidal processes can be easily quantified, and b) any impacts on sediment transport must be a result of the physical circulation. If impacts on physical circulation are absent, then there can be no impacts on sediment transport.

Two hypotheses are considered:

H1: The daily tidal exchange and tidal prism of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

H2: Specific tidal species and tidal constituents of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

[1] Technical terms are defined in a Glossary at the end of the report.

River flow is considered as an additional perturbation to the tides, because its effects on the bay are likely to be larger than those of the MBPP intake flow. Although the methods employed have been used in other estuaries, detection of river flow effects on Morro Bay tides provides an additional form of validation of the methods used. Moreover, analysis of river flow effects serves to put the MBPP intake flow in context as a minor perturbation to the bay's physical processes.

Hypothesis H1 is considered because of its ecological significance to Morro Bay – if MBPP intake flow actually does influence tidal exchange and the tidal prism, then the MBPP intake flow might affect sediment transport and shoaling patterns in the bay. Conversely, if the MBPP does not influence the large-scale tidal processes of the bay, then impacts on sediment transport processes and shoaling are unlikely. Hypothesis H2 addresses the individual tidal processes that collectively create the tidal prism. It is considered in order to: a) explain the results of H1, b) increase the sensitivity of the analysis tools employed, and c) verify that the methods used are effective. If there is an influence of low- frequency flow processes on the tidal prism (i.e., a positive result for H1), then this must be explicable in terms of specific tidal processes analyzed in H2. Furthermore, modern tidal analysis methods dissect the tidal species into their component parts and remove the dominant tidal monthly variations in tidal processes. This approach provides a very sensitive test of impacts on the bay. Therefore, if there is a negative result for the smaller tidal constituents in H2, this provides strong support for a negative result for H1. Finally, the positive result achieved for H2 with regard to river flow indicates that any effects of the MBPP intake would have been detected, if any existed.

The analyses described in this report consider two aspects of the tides: a) the rise and fall of the tide, as measured by surface elevation records, and b) the tidal exchange, as measured by a current meter. There is, moreover, a direct linear relationship between tidal range and tidal prism volume – any change in one implies a change in the other. Thus, a positive result for H1 or H2 in analyses of either tidal elevation or tidal currents implies a positive result for the other variable.

Tidal theory suggests, moreover, that the presence of a mean flow can decrease the tidal range and tidal exchange of an estuary, if the mean flow is large enough and acts over a long enough distance. This decrease in tidal action occurs through a frictional interaction between the tidal and mean flows. This frictional interaction, acting over distance, dissipates tidal energy and distorts the tidal wave. The MBPP intake flow varies only from 0 to ~9% of the tidal prism, while river flow can be much larger, ~10% (2-yr flood event) to >250% (100 year flow event) of the average tidal prism. Still, both MBPP intake flow and river flow act over a limited distance. Thus, although the tidal prism (the subject of H1) is an important ecological indicator, it is not particularly sensitive to non-tidal perturbations to Morro Bay. On the other hand, some of the smaller, non-linearly generated components of the tide (known as overtides) are potentially very sensitive to the presence of mean flow. Also, any effects of river inflow and MBPP intake flow on Morro Bay overtides can be distinguished by their temporal and spatial patterns. Looking at the spatial and temporal variability of selected overtides (the subject of H2) provides, therefore, an extremely sensitive test for any influence of mean flows on tidal properties. If the effect of these mean flow processes cannot be seen even in the overtide records in H2, these effects are indeed very small, well below the threshold level for ecological significance.

The tidal elevation data employed here were collected at two stations in the bay by Tetra Tech between 9 March and 10 April 1998 (Tetra Tech, 1999). Of these two stations, MBN is near the mouth of the bay and the Morro Bay Power Plant. Station MBS is in mid-bay near the river deltas. These two stations are well situated to capture spatial variations of tidal properties in the bay. The sampling period encompasses small fluctuations in river flow related to the passage of several storms and a variable MBPP intake flow volume. However, the plant operated to some degree during the entire period, so the MBPP intake volume never dropped to zero.

The current meter data analyzed here were collected at a single station near Fairbank Point by PGE between November 1995 and January 1997. This data set covers almost the entire range of MBPP operation levels and a substantial river flow range as well. There is, however, a gap of four months between deployments in the middle of the record. The deployment location for the current meter is ideal for determining whether there are any effects of the MBPP on the more landward portions of the bay.

Two tidal analysis methods were employed in this report. Harmonic analysis, the traditional method used for tidal prediction, was used to quantify the average tidal processes in Morro Bay. Harmonic analysis assumes that tidal properties and processes are independent of all outside perturbations, i.e., that the tides are statistically stationary. It is, however, precisely the non-stationary response of the tides to mean flows that is tested through H1 and H2. Non-stationary tidal responses are sought using continuous wavelet transform analyses, a method designed to measure the evolving frequency content of a process, e.g., tides.

Hypothesis H1 was tested using the month of tidal elevation data collected by Tetra Tech in spring 1998. Results for H1 were negative, for both MBPP intake flow and river inflow. MBPP intake flow varied from ~150 to 360 MGD during the March-April 1998 period during which the Tetra Tech tidal elevation data were collected. This intake flow range corresponds to a range in the ratio of intake flow to tidal prism of ~1.2 to 4.2%. The total possible range of the ratio of intake flow to tidal prism is zero (no plant operation) to ~9% (full operation during the weakest neap tide). The range of plant operation that occurred during March-April 1998 did not produce any detectable perturbations to the tidal prism at station MBN (near the MBPP plant) or at station MBS (in the interior of the bay). River flow into Morro Bay during the March-April 1998 period was only ~0.02 to 1% of the tidal prism. This is not high enough to produce any noticeable perturbation of the tides. Higher river flows in the range of 5-30% of the tidal prism do occur at intervals of ~6 mo to 5 yrs and do perturb the tides, thereby affecting sediment transport.

Results for H2a were negative for both the 1998 tidal elevation data and the 1995-97 current meter data. This negative outcome for the primary components of the tide (the diurnal [D_1] and semidiurnal or [D_2] tidal species) strongly reinforces the conclusions for H1, because the behavior of D_1 and D_2 waves governs the size of the tidal prism. Tests were also conducted for non-linearly generated overtides, because these are quite sensitive to non-tidal perturbations. These tests focused on the two largest overtides in the bay, the quarterdiurnal and six-diurnal species (D_4 and D_6). Also, specific predictions were available as to the reactions of D_4 and D_6 to the presence of a mean flow.

Results for Hypothesis H2a (the effects of MBPP intake flow on tidal exchange) were consistent with those for Hypothesis H1a (the effect of MBPP intake flow on tidal range). No effects of MBPP operation were detectable in the interior of the bay (using both surface elevation and current data) or near the MBPP itself (where only surface elevation data were available). This test is quite conclusive in that the current meter data cover almost the entire range of MBPP intake flow, ~50 –612 MGD (compared to a total range of 0 – 668 MGD). This negative for Hypotheses H1a and H2a means that adverse effects of the MBPP intake flow on shoaling processes in the interior of the bay are excluded. It is not possible for the MBPP to effect sediment transport in the very shallow waters landward of Fairbank Point without acting through the tidal currents. This analysis cannot, however, exclude the possibility that the MBPP has subtle effects on tidal exchange, currents and sediment transport near the estuary entrance.

There is a very strong contrast between the negative results for Hypotheses H1a and H2a and the positive results for Hypotheses H2b (the effects of river inflow on tidal processes in the bay). The tidal dynamics of the bay respond strongly to river inflow – a decrease in tidal exchange was evident for river flow levels less than half of the maximum MBPP intake flow level. River inflow also strongly influences the sediment dynamics of the bay, both because high river inflow brings with it large amounts of sediment, and because river inflow changes the tidal dynamics and estuarine circulation of the bay in such a way as to favor sediment retention.

Finally, the analysis methods employed to test Hypotheses H1 and H2 were quite sensitive, as is evident from the positive results for Hypotheses H2b for river inflow levels of about half the maximum MBPP intake flow (equivalent to one-third of the two-year return flow).

In summary, analyses of tidal current and surface elevation records do not support the idea that MBPP intake flow affects the tidal regime of the interior of Morro Bay. The analysis methods used were sensitive enough, moreover, to capture changes in tidal properties caused by brief high river-flow events. High river flow decreases the tidal range and the amplitudes of the principal tidal species, and alters the distribution of energy between overtide species. Successful detection of river flow-induced perturbations of the tidal regime at river flow levels less than half of full MBPP plant operation conclusively demonstrates the sensitivity of the analysis methods used. Were there any effects of the MBPP intake flow on the tidal circulation processes in the interior of Morro Bay, they would have been detected.

2. Introduction

The Morro Bay Power Plant (MBPP) is located near the entrance to Morro Bay (Figure 2.1). The plant uses cooling water from Morro Bay and discharges the heated effluent to the ocean north of Morro Rock, outside of the bay. The volume of the intake flow is variable, depending on the level of plant operation. The minimum discharge is zero (with the plant not in operation); maximum discharge is 668 million gallons day^{-1} (MGD), equivalent to ~1,000 cubic feet per second (ft^{3}s^{-1}) or 28 m^{3}s^{-1}. When the MBPP is operating, the intake flow creates a current near the entrance of the bay. This mean flow moves in a landward direction from the mouth of the bay toward the plant. Landward of the plant this mean flow does not exist. In addition to the MBPP intake flow, there are two tributary streams to the bay that also create a mean flow. The tributaries are Chorro and Los Osos Creeks. Much of the year, flow in these streams is very low, and their influence on the bay is limited. Their maximum river flow is, however, larger than the MBPP intake flow, 1,560 ft^{3}s^{-1} (~44 m^{3}s^{-1}) for the sum of the two-year return flows of Chorro and Los Osos Creeks (Tetra Tech, 1998). These creeks enter the bay on its east side, somewhat more than half way to the head of the bay. They create, therefore, a mean flow from the land to the ocean that extends from mid-bay to the ocean.

The possible impacts of the MBPP intake flow on tidal processes in Morro Bay have arisen as an issue in the Application for Certification process. The concern is that the MBPP intake flow decreases the tidal prism of the bay or in some other way affects tidal processes and, therefore, long-term shoaling patterns. This report describes analyses that evaluate whether this concern is valid. To insure a rigorous approach, the analyses are posed in terms of formal hypotheses, and state-of-the-art tidal analysis methods are used for hypothesis tests. The focus is on tidal processes (instead of sediment transport *per se*) because:

- Tidal processes can be easily quantified.
- Any impacts on sediment transport must be a result of the physical circulation. If impacts on physical circulation are absent, then there can be no impacts on sediment transport.
- Given the very shallow water of back bay (mean depth <2 m relative to Mean Lower Low Water or MLLW), tidal circulation is the dominant circulation process.

A focus on tidal processes is, therefore, appropriate. The data analyses described below utilize two data sets. The first is a month of tidal elevation data collected by Tetra Tech during March-April 1998 (Tetra Tech, 1999). This period is favorable for analyses, because MBPP intake flow was quite variable, and two tide gauges are available in the bay. The second data set employed is a current meter record (collected by an InterOcean S4 current meter) extending from November 1995 to January 1997, with a four-month gap in spring-summer 1996. This is the longest physical data record available for the system. It covers almost the total range of MBPP intake flow and a reasonable range of river flow, up to 457 $ft^3\ s^{-1}$ for Chorro Creek.

The two hypotheses considered are:

H1: The daily tidal exchange and tidal prism[2] *of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.*

H2: Specific tidal species and tidal constituent of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

Baroclinic processes (those involving internal salinity and density differences) are not considered in the hypotheses, because the interior of the bay is very shallow and density differences are small, except during major river-flow events. Both river flow and the MBPP plant inflows are considered in the hypothesis scheme, because: a) the same tide-mean flow frictional interactions apply to both, and b) the effects of the river flow provide a demonstration of the sensitivity of the method. Although river flow creates a mean flow from the bay to the ocean and the MBPP intake flow is in the opposite direction, the underlying physical processes are the same. Successful detection of river flow effects on Morro Bay tides in the analyses described below confirms the sensitivity of the analysis methods employed.

Hypothesis H1 is considered because of its ecological significance to Morro Bay. If MBPP intake flow actually did influence tidal exchange and the tidal prism, then it might also affect sediment transport in the bay. Conversely, if the MBPP does not influence the large-scale tidal processes of the bay, then impacts on sediment transport processes and shoaling in the interior of the bay are highly unlikely. Hypothesis H2 addresses the individual tidal processes that collectively create the tidal prism. It is considered to clarify and validate the results for H1. If

[2] Technical terms are defined in a Glossary, at the end of the report.

there is an influence of either of the above low-frequency flow processes on the tidal prism (i.e., a positive result in H1), then this must be explicable in terms of positive result for specific tidal species or constituents in H2. Furthermore, the tidal prism is a bulk parameter that is the net result of the overall tidal dynamics of the bay. As such, it is much less sensitive to non-tidal perturbations than some of smaller individual tidal species and constituents. Modern tidal analysis methods make it possible, moreover, to remove the dominant neap-spring effects seen in the tidal range and focus individually on the smaller (overtide) species (in H2). This approach provides a very sensitive test of impacts on the bay. Changes in overtides that might alter sediment transport patterns can be detected, if any such exist. Therefore, if there is a negative result for the smaller tidal constituents in H2, this provides strong support for a negative result for H1. Moreover, a positive result in H2 is possible, even though the result for H1 is negative. A positive result in H1 with a negative result in H2 would, however, indicate methodological problems.

The analyses described in this report consider two aspects of the tides: a) the rise and fall of the tide, as measured by surface elevation records, and b) the tidal exchange, as measured by a current meter. There is, moreover, a direct linear relationship between tidal range and tidal prism volume – any change in one implies a change in the other. Thus, a positive result for H1 or H2 in analyses of either tidal elevation or tidal currents implies a positive result for the other variable.

The tidal elevation data employed here were collected at two stations in the bay by Tetra Tech between 9 March and 10 April 1998 (Tetra Tech, 1999). Of these two stations, MBN is near the mouth of the bay and the Morro Bay Power Plant. Station MBS is in mid-bay near the river deltas. These two stations are well situated to capture spatial variations of tidal properties in the bay. The sampling period encompasses small fluctuations in river flow related to the passage of several storms and a variable MBPP intake flow volume. However, the plant operated to some degree during the entire period, so the MBPP intake volume never dropped to zero.

The PG&E current meter data analyzed here were collected at a station near Fairbank Point between November 1995 and January 1997. This data set covers most of the range of MBPP operation levels and a substantial river flow range as well. There is, however, a gap of four months between deployments in the middle of the record. The deployment at Fairbank Point is ideal for detecting any effects of the MBPP on the more landward portions of the bay.

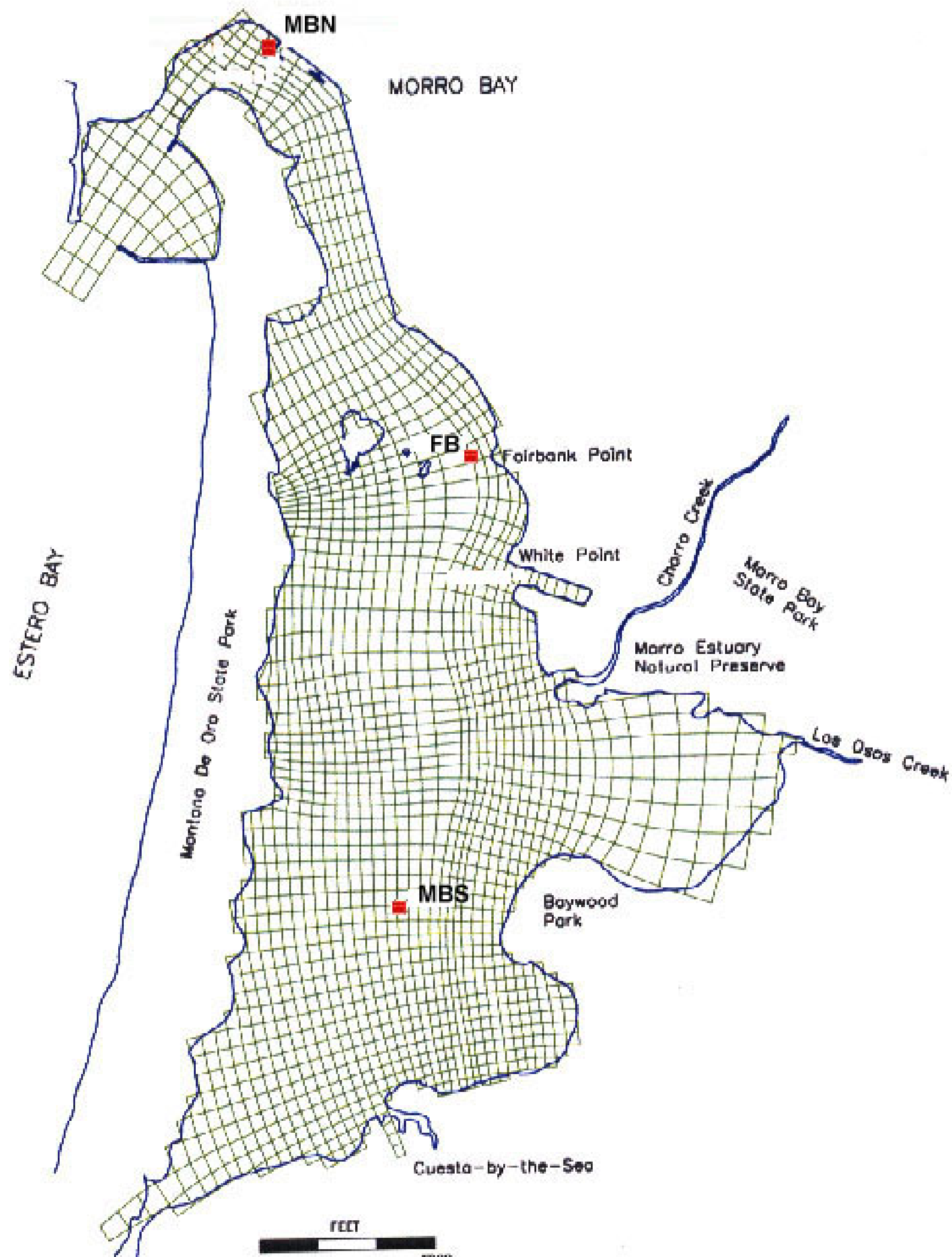


Figure 2.1: *Station locations for the data analyzed in this report. The data include: a) two 1998 Tetra Tech pressure gauges (from which tidal height is calculated); stations MBS and MBN (Tetra Tech, 1999), and b) the 1995-97 PGE current meter located and near Fairbank Point (FB). The MBPP intake flow structure is located on the shore NW of station MBN. Figure modified from Tetra Tech (1999).*

3. <u>Setting</u>

3.1. Morro Bay – General Characteristics

Morro Bay is a shallow, seasonally hyper-saline, bar-built estuary, a type of system often referred to as a lagoon or barrier-lagoon (Orme, 1991). It is situated behind a barrier sand spit formed by littoral transport north from the vicinity of Pt. Buchon. This natural (south) barrier spit separates the bay and the delta of Chorro and Los Osos Creek from the more open waters of Estero Bay. The south spit is cut off from Morro Rock by the dredged navigation channel. This modern entrance is one of two original entrances. A smaller (north) sand spit connects Morro Rock to the mainland. This spit is artificial, and was constructed to close a second natural entrance to the bay north of Morro Rock.

Morro Bay is of recent (Holocene) origin – it has assumed approximately its present form since the relative stabilization of sealevel ca. 6-7,000 Years Before Present (YBP). Orme (1991) estimates that the barrier spit likely formed between 3,500 and 5,000 YBP. Like most estuaries, Morro Bay is a transient feature in geological terms, and it is vulnerable to filling by dredged material disposal, sedimentation from tributary creeks, migration of its sand spit, tectonic changes, and global sealevel rise.

The total surface area of Morro Bay is approximately 3.3 mi^2. Much of the Bay is intertidal, so that the area of open water at low tide (the subtidal area) is considerably smaller – <1 mi^2 (Tetra Tech, 1999). The subtidal volume is ca. 4,400 ac ft, giving an average depth of the subtidal part of the bay of 8.4 ft below Mean Lower Low Water (MLLW) or 11.3 ft below Mean Tide Level (MTL). The area of the system below Mean High Water (MHW) is ~11,470 ac. ft., yielding an average depth for the system as a whole of ~3.8 ft below MTL. Since MTL is 2.9 ft above MLLW, the average level of the sea bed within the bay is close to 1 ft below MLLW. This very shallow average depth and the contrast between the depths of the subtidal and inter-tidal areas reflects the presence of relatively narrow channels through a considerable expanse of intertidal flats and marsh.

One of the more notable features of Morro Bay is that its freshwater supply is not at its head or most distant point from the entrance, as is typical for an estuary. Instead the primary freshwater sources, Chorro and Los Osos Creeks, enter the middle of the bay, between Baywood Park and White Point. This geometry is reflected in flushing time and salinity patterns in the bay makes the back bay area landward of the deltas particularly susceptible to shoaling. This area is amply supplied with sediment from the tributary streams, but there is no corresponding fluvial net flow in this part of the bay to remove the sediment supplied.

3.2. Morro Bay -- Freshwater Inflow

An estuary is traditionally defined as a semi-enclosed coastal water body where seawater is diluted by freshwater derived from land drainage (Dyer, 1997). Freshwater inflow is, therefore, a vital part of any estuarine system. Morro Bay receives freshwater input from the seasonally variable flows of Chorro and Los Osos Creeks. Total watershed of the creeks encompasses approximately 48,000 acres, only about 23 times the total surface area of the bay. This small ratio of watershed to estuary area marks Morro Bay as a marine-dominated system. Because of the small catchment area, average flows for these tributaries are quite small, and peak flows are of more importance to the system. Tetra Tech (1999) used the following values for numerical model simulations:

- Summer low flow: 1.4 and 0.3 ft^3s^{-1} for Chorro and Los Osos Creeks, respectively.
- Medium flow: 64 and 3.3 ft^3s^{-1} for Chorro and Los Osos Creeks, respectively.
- “Extreme” high flow: 1,146 and 203 ft^3s^{-1} for Chorro and Los Osos Creeks, respectively. These values are somewhat less than the 2-year flood level for Chorro Creek (1,476 cfs) and between the 2-year (84 cfs) and 5-year (566 cfs) flood level for Los Osos Creek (Tetra Tech, 1998).

The total 2-yr event flow (1,560 cfs) is ~10% of the tidal prism. Much higher flows occur at longer intervals. The 5, 10, 25, and 100-year flood levels for Chorro Creek are estimated to be 4,588, 8,640, 16,669 and 35,390 cfs, respectively (Tetra Tech, 1998). The corresponding figures for Los Osos Creek are 566, 1,374, 3,245 and 7,994 cfs, respectively. The total river inflows (sum of the flows for Chorro and Los Osos Creeks) for the 5, 10, 25, and 100-year flood events are 5,154, 10,014, 19,914, and 43,384 cfs, respectively. These values are 33, 64, 127 and 278%

(respectively) of the greater daily tidal flux. These extreme flow levels will certainly affect tidal processes when they occur, but the total duration of extreme flows is very short.

High river flow events are expected to have much larger effects on the sediment transport regimes of the bay than the MBPP power plant for several reasons:

- The river flow enters Morro Bay in its middle portion, south of Fairbank Point, where the bay is very shallow. River flow will, therefore, create more bed friction over a larger part of the bay than the MBPP intake flow, which exists only near the mouth of the bay, where the channel is relatively deep.
- River flow events are accompanied by very large inputs of fine, suspended sediment, whereas the MBPP intake flow brings marine waters with little suspended material into the system. Material from tributary creeks has caused considerable shoaling of the delta and back bay areas over the last 120 years (Haltiner and Thor, 1988, 1991).
- Sediment transport varies approximately with the cube of the velocity above a threshold. Thus, relatively infrequent events have a very large impact. Tetra Tech (1998) estimated, for example, that the 10 yr flow event in Chorro Creek brings in about 28 times as much sediment as the 2 yr event.
- The non-linear interactions of tides with a mean flow vary with the square or cube of velocity. Thus, small mean flows have negligible effects, but tide-mean flow interactions grow rapidly with the mean flow.

This study uses flow from Chorro Creek River, the larger of the two tributaries as a surrogate for total river inflow. At high flow levels, Chorro Creek provides 80-90% of the total flow. Because flow fluctuations are more important than absolute flow values to the analysis, this approximation does not affect the conclusions drawn.

4. <u>Tidal Processes</u>

4.1. *Tidal Species and Tidal Constituents*

The analyses in Section 7 are based on a background knowledge regarding estuarine tidal processes that is common to all estuaries. The necessary definitions and relationships are supplied in this section.

The observed tide at the mouth of Morro Bay is the result of the gravitational attraction of the sun and moon acting on the waters of the Pacific Ocean. This gravitational forcing occurs at specific frequencies that are known from astronomical considerations. There are two principal components (known as "tidal species") to the astronomical tide:

- The diurnal or once-daily tidal wave. This tidal species is denoted as the D_1 tide.
- The semidiurnal or twice daily tidal wave. This tidal species is denoted as the D_2 tide.

The tides on the West Coast of the United States are a mixture of the diurnal and semidiurnal waves, with the D_2 wave being larger than the D_1 wave at most locations. The ratio of the D_2 tide to the D_1 tide in Morro Bay is about 1.1:1.

A tidal wave impinging on Morro Bay from the open ocean is modified and distorted by the shallow water of the bay. The result is production of additional tidal species with frequencies higher than D_1 and D_2. These higher-frequency waves are generated by interactions of the main tidal species that can be defined through analysis of the fundamental equations governing tidal motion. Such non-linear tidal species or "overtides" are weak or absent in the open ocean. The overtides relevant here are:

- The terdiurnal or three-times daily tidal wave. This tidal species is denoted as D_3.
- The quarterdiurnal or four-times daily tidal wave, denoted D_4.
- The six-diurnal or six-times daily tidal wave, denoted as D_6.
- The eighth-diurnal or eight-times daily tidal wave, denoted as D_8.

All the tidal species are observable physical realities as well as mathematical concepts. The diurnal and semidiurnal waves represent the once and twice daily movements of water in and out of the bay in response to the gravitational pull of the sun and moon on the water of the Pacific Ocean. The non-linear species represent the distortion of the tidal species incident from the ocean by propagation through the shallow water of the bay. Each tidal species has a mathematical representation (in terms of a complex number with time-variable amplitude and phase). It is sometimes useful, moreover, to represent each tidal species as the sum of specific "tidal constituents" whose frequencies are determined from astronomy. Each tidal constituent can also be represented as a complex number (having an amplitude and phase). The tidal constituents for each tidal species have frequencies that are close to one another. Thus, the sum of tidal constituents that represents a tidal species has properties that vary slowly in time. This slow variation of the tidal species properties is much like the beat frequency of two musical instruments that are almost, but not quite, in tune.

Tidal constituents are convenient mathematical abstractions that often do not have the same physical reality as the tidal species. Their utility comes from the fact that a successful representation of a tidal species (by a tidal harmonic analysis) results in tidal constituents that are essentially constant in time. That is, harmonic analysis of surface elevation data for a station from one year will produce essentially the same collection of tidal constituents as an analysis of data for that station for any other year. Because of the invariance in time of the tidal constituents for many locations, harmonic analysis provides a powerful method of tidal prediction. This apparent invariance of tidal constituents is perhaps, however, illusory in the present case. Affirmation of either of the above two hypotheses would mean that the tidal constituents used to represent tidal species were not invariant, but changed in time with the volume of river inflow or MBPP cooling intake. Conventional tidal analysis methods presume that the tides are "statistically stationary"; i.e., that they have a statistical invariance in time that validates a representation in terms of time-invariant tidal constituents. Application of such a method would prevent a valid test of the two hypotheses. A less conventional but more flexible wavelet transform tidal analysis approach is used here, as discussed in the next section. This approach allows a valid test of the two hypotheses to be performed.

4.2. *Tides in Shallow Bays*

It is important to briefly consider how shallow water tidal propagation affects the tidal heights in an embayment. These considerations make it possible to define exactly which properties of the tide are most sensitive to the presence of a mean flow. This allows a test of H2, which represents a much more sensitive look at Morro Bay tides than is the case for H1.

Tidal propagation in shallow embayments is governed by five primary factors (Jay, 1991; Friedrichs and Aubrey, 1994; Lanzoni and Seminara, 1998):

- The amplitude of the tide relative to the mean depth of the embayment.
- The shape of the embayment, specifically its length and the rate at which depth and width change along the embayment.
- The size and shape of the tidal flats along the banks of the embayment.
- The strength of the friction against the bed.
- The presence and position of mean flows, the MBPP intake flow and river flow in this case.

All of these factors affect both surface elevation and tidal currents. There are additional factors, discussed below, that affect primarily tidal currents without leaving much trace in the tidal elevation record.

Morro Bay is very shallow, with a mean depth of only ~3.8 ft (1.2 m) relative to Mean Tide Level (MTL). The mean daily tidal amplitude (half the range between MHHW and MLLW) in Morro Bay is ~2.7 ft (0.82 m), yielding a ratio of tidal amplitude to depth of ~0.7. This suggests that the tides in the bay should be highly distorted. Also, the cross-sectional area of the bay decreases sharply from the mouth (where an artificially large cross-section is maintained by dredging) to the head of the bay. This geometry is termed "convergent" and may lead to amplification of the tide, because the tidal wave is continually funneled into a smaller cross-section. However, the bay is also very short relative to the wavelength of the major tidal species. This fact limits: a) the possibility of tidal amplification through funneling or resonance, and b) the degree of distortion of the wave that can occur. Furthermore, most of the surface area of the bay is intertidal, with the subtidal volume of the system mostly near the entrance. Because most of the bay is so shallow, bed friction is strong, even without mean flows. Mean flows affect tidal dynamics primarily by increasing the strength of bed friction. Whether this effect is of any practical importance in Morro Bay is tested through hypotheses H1 and H2.

The information in the previous paragraph can be used to provide specific predictions of how tidal processes (and surface elevation in general) will be affected by propagation in a short, shallow and convergent bay like Morro Bay. These predictions are used to test the above two hypotheses. These predictions relate to:

- The amplification of the basic D_1 and D_2 waves in the system.
- The opposing effects of wave distortion related to shallow depths versus distortion due to the presence of tidal flats.
- Loss of tidal energy due to bed friction.
- An increase in frictional energy loss due to the presence of mean flows. This factor is considered in the next section.

Amplification: Morro Bay is convergent, a situation typically leading to an increase in the amplitude of the D_1 and D_2 waves toward the head of the estuary. The bay is also very short and highly frictional, which sharply limits the degree of amplification that can be observed. We expected, therefore, only a very modest tidal amplification towards the head of the bay.

Wave distortion: Tidal distortion can be understood in part by analogy to waves on a beach. Just as a wind wave shoaling on a beach steepens (the crests overtake the trough), a tidal wave propagating in a shallow bay will steepen, if the ratio of tidal amplitude to mean depth is appreciable. However, tidal flats introduce a factor not present in the case of wind waves. Tidal variations in estuarine width (caused by the presence of tidal flats) introduce a wave distortion of the opposite sense (the troughs overtake the crests), if the tide floods through a larger cross-sectional area than it ebbs. Either sort of wave distortion varies with the square of the tidal amplitude in the bay. Because both peak flood and peak ebb occur in Morro Bay at about the same elevation (MTL on the average), the wave distortion observed in Morro Bay is expected to be related to tidal variations in depth (wave steepening). In a tidal analysis, this distortion of the D_2 wave causes growth of overtides D_4 and D_8 toward the head of the bay. Both should, however, remain small in a bay as short as Morro Bay. Because the D_1 wave is smaller than the D_2 wave, distortion of the D_1 wave is visible primarily through growth toward the head of the bay of overtides related to the interaction of D_1 with D_2, in this case D_3 and D_6. On the whole, however, wave distortion effects are usually small in a bay of this sort.

Bed friction: Frictional energy loss at the seabed is usually the largest factor affecting the observed tidal species and constituents in a shallow bay. The bedstress on a tidal wave (i.e., the retardation of wave propagation by friction at the bed) is proportional to $C_D|U|U$, where C_D is a constant (the drag coefficient ~0.003), U is total velocity, and | | is absolute value. This bedstress can be expressed as (Dronkers. 1964):

$$C_D|U|U \cong a\,U + b\,U^2 + c\,U^3 \qquad (1)$$

Where the coefficients *a, b, c* are functions of the ratio of mean flow velocity $\langle U \rangle$ to tidal velocity U_T. If the mean flow velocity goes to zero, $a = 8/3\pi$, $b = 0$, and $c = a/5$. The fact that $a > 0$ means that all tidal constituents will be damped to zero if an embayment is large enough, but this occurs only over a distance much greater than the length of Morro Bay. The fact that $c \neq 0$ means that toward the head of the bay: a) energy loss from the D_1 wave will cause the growth of D_3 relative to D_1, and b) energy loss from the D_2 wave will cause the growth of D_6 relative to D_2. D_2 is larger than D_1 in Morro Bay, and frictional energy loss is usually the largest single factor structuring the distribution of tidal species and constituents in a shallow bay (Parker, 1991). Therefore, of all the effects of tidal propagation in Morro Bay, growth of D_6 toward the head of the bay should be the most prominent. Nonetheless, Morro Bay is so short that this growth should remain modest.

Mean flows: The effects of a mean flow on tidal processes is the subject of the next section.

4.3. *The Effects of Mean Flows on Tidal Propagation*

The presence of a mean flow causes an increase in the tidal energy loss to bed friction, over and above that caused by propagation of the tidal wave itself. This increase in frictional energy loss manifests itself as:

- Changes in the frequency distribution of the tidal energy – some species increase in amplitude and others decrease.
- Changes in the spatial distribution of the tidal energy – the ratios of tidal energy at the various tide stations in the bay may change.

This can be explained in terms of eq. 1 by considering the values of *a, b*, and *c* as the ratio of mean flow to tidal flow becomes large. In such a circumstance, $a = c = 0$, and $b = \pi$. The presence of even a small mean flow (as in Morro Bay) causes *a* and *c* to decrease and *b* to grow.

There are two primary predictions related to the distribution of tidal species and constituents in the bay:

- Spatial variations in the major tidal species, D_1 and D_2: It is observed in the landward reaches of tidal rivers that there is a decrease (at any fixed location) with river flow in the tidal amplitude from a base, low-flow amplitude. This decrease is proportional to the square root of the river flow, and the proportionality constant grows in the landward direction (Jay and Flinchem, 1997). Thus, tides 18 miles from the mouth of the Columbia River are only marginally affected by river flow, whereas tidal amplitude varies seasonally by a factor of three to ten or more at stations 50 to 150 miles from the ocean. Because Morro Bay is only ~3 miles long and the mean flows (the MBPP intake flow and the river inflow) are modest (much less than in the Columbia), mean-flow effect on D_1 and D_2 are likely to be small. If any river flow effect on the major tidal species is to be found, it should be seen near the mouths of the tributaries (Chorro and Los Osos Creeks) during and after major storms.
- Spatial variations in overtide structure: River inflow causes all tidal constituents in a large tidal river or estuary to be strongly damped as distance from the ocean increases. Still, friction from river inflow can cause the growth of overtides at the expense of the major tidal species near the mouth of a system. Thus in the Columbia, Jay and Flinchem (1997) found that the amplitude of overtide D_4 decreased in an absolute sense with river flow, but that there was an increase in D_4 relative to D_2. Close to the mouth of an estuary, there can be an increase in D_4 in both the relative and absolute senses, but the relative increase should be easier to detect than the absolute one. This behavior can be explained in terms of the changes with river flow of the coefficients in eq. 1. Interactions of mean flow and the tidal flow are

related to coefficient *b* in eq. 1. At any fixed station, *b* increases with increasing mean flow (relative to tidal velocity). For any fixed mean flow, *b* increases in the landward direction. Thus, increasing river flow will eventually damp all tidal species in a large river estuary, and the greater the river flow, the closer to the mouth tidal motion will cease to be perceptible. In a very short system like Morro Bay, another effect is likely to be more prominent. Coefficient *b* is zero in the absence of mean flow, but increases with river flow. Thus, the presence of a mean flow (which increases *b*) can increase the generation of quadratic overtides like D_4 (caused by the interaction of D_2 with itself), which would otherwise be less prominent in Morro Bay than D_6. In contrast, *c* (the coefficient in eq. 1 responsible for generation of D_6) decreases as mean flow increases. This should damp D_6 as mean flow increases. The loss of energy to D_6 may, however, not be as rapid as that for D_2, because overtides have multiple generation mechanisms. Because of the generation mechanisms involved and the potentially large relative changes in overtide amplitudes, it is more likely that effects of a mean flow can be seen in the overtides than in the tidal range or the major tidal species (D_1 and D_2).

The specific circumstances of mean flows in Morro Bay should also be considered in designing hypothesis tests. There are two important factors: a) the temporal evolution of the mean flows, and b) their spatial distribution. Both factors can be used to detect mean flow effects and to distinguish (potentially) the river flow and MBPP inflow signals from one another.

- Temporal evolution: River inflow to Morro Bay is usually small, but shows sporadic peaks. If effects of river inflow on tides are to be found, it will be during and shortly after storms; these usually occur during the winter (November to March). MBPP intake volume varies seasonally and, in some seasons, from day-to-day. If there is an effect of the power plant on the tide, it can only be detected during periods when use of the plant varies from day-to-day.
- Spatial distribution: The frictional effects of a mean flow on tidal processes occur because friction acts over a distance. Inflow from Chorro and Los Osos Creeks occurs in the middle of the bay, and there is a mean flow associated with the presence of river inflow between the ocean entrance and the mouths of these creeks. There may also be an eddy circulation near the head of the bay driven by river flow. Thus, river-flow friction throughout the bay should cause the signal to evolve toward the head of the bay. The largest effects of river inflow on Morro Bay should be observable in the overtides at tide gauges located in mid-bay, or even

towards the head of the bay. In contrast, the mean flow associated with the MBPP occurs only between the ocean entrance and the power plant, which is <1 mi. inside the bay. Thus, the effect of friction occurs only over a limited reach between the entrance and the power plant. There is no reason to expect further evolution of the tidal effects of the plant anywhere landward of the plant, even in the overtides. Thus, a gauge near the plant should show the same temporal pattern as one elsewhere in the bay. This difference in spatial distribution of effects provides a second means to distinguish river inflow and MBPP intake flow effects on Morro Bay tides, should any mean flow effects be observable.

In summary, tidal theory suggests that the presence of a mean flow can decrease the tidal range of an estuary, if the mean flow is large enough and acts over a long enough distance. The MBPP intake flow varies only from 0 to ~9% of the tidal prism, while river flow can be ~10% (2-yr flood event) to >250% (100-year flow event) of the tidal prism. Both MBPP intake flow and river flow act over a limited distance. Thus, it is unlikely that any decrease in tidal range can actually be measured in H1, except perhaps at river flows approaching the 5-yr event level. On the other hand, overtides D_3 and D_4 (which should increase with mean flow) and D_6 (which should decrease with mean flow) are very sensitive to the presence of mean flow. Furthermore, any effects of river inflow and MBPP intake flow on Morro Bay overtides can be distinguished by their temporal and spatial patterns. Looking at the spatial and temporal variability of selected overtides (H2) provides, therefore, an extremely sensitive test for any influence of mean flows on tidal properties. If the effect of these mean flow processes cannot be seen even in the overtides records, these effects are indeed very small, well below the level of ecological significance.

4.4. *Tidal Currents in a Shallow Bay*

Topography, wave distortion, bed friction and the presence of a mean flow affect tidal currents just as much as they affect tidal elevation. There are several additional mechanisms that affect tidal currents to a much greater degree than tidal elevations. The differences between tidal currents and tidal elevation arise primarily from the fact that surface elevation is an integral measure of processes throughout the water column, whereas tidal currents are measured at a single point in the water column. Tidal currents are, therefore, inherently more variable than surface elevation.

There are two processes likely to be important in the Morro Bay currents analyzed here:

- Lateral currents or secondary circulation. When the flow in a channel rounds a bend, then the surface elevation is higher on the outside of the bed. In a steady flow like a river, this results in a steady lateral circulation, toward the outside of the bend at the surface and toward the inside of the bend at the bed. In a reversing tidal flow, the strength of this lateral circulation varies tidally, being strong on flood and ebb, and vanishing at slack water, between flood and ebb. Thus, the lateral circulation has two maxima per tidal cycle (one on flood and one on ebb) and two minima (at each slack water). In contrast, the alongchannel circulation has one maximum (peak flood) and one minimum (peak ebb) during each tidal cycle. Lateral circulation in a tidal channel then doubles the frequency of the basic tidal forcing – alongchannel D_2 currents lead to a D_4 lateral circulation. The interaction of alongchannel D_1 and D_2 currents leads to a D_3 lateral circulation. Lateral circulation effects are often quite evident in current data, but are hard to detect in surface elevation data, unless tide gauges are placed on both banks of a channel bend.

- Flood-ebb differences in the distribution of alongchannel currents in the water column. These may arise from:

1. Tidal variations in salinity and density. When the vertical salinity stratification varies tidally, then the vertical mixing regime is different on flood and ebb, changing vertical mixing and current patterns. This process is known as internal tidal asymmetry (Jay and Musiak, 1996). It is likely present during periods of high river flow, but absent otherwise. It will be undetectable in surface elevation data.

2. The channel curvature is greater landward of Fairbank Point than seaward of it. When the degree channel curvature varies along a channel, then flood and ebb currents will be pushed by centrifugal acceleration toward the bank to different degrees, affecting both the lateral distribution of alongchannel currents and the strength of lateral currents. This process is evident throughout the current data record, but is hard to detect in surface elevation records.

The current data here are from a single instrument. They do not allow elucidation of complex current patterns within the Fairbank cross-section or define differences between estuarine cross-sections. The proposed hypothesis tests do not require, however, that all the details of the current regime be resolved. The distinctive temporal patterns of MBPP intake flow and river flow will allow their effects to be detected, if they are important.

5. Tidal Analysis Methods

Tests of hypothesis H1 and H2 require that surface elevation and current meter records be analyzed to quantify the tidal information contained therein. Two types of tidal analyses are used: harmonic analysis (Foreman, 1977), and a continuous wavelet transform approach (Jay and Flinchem, 1997; Flinchem and Jay, 2000). The former is used to quantify the average tidal processes in Morro Bay. The latter is specifically designed to detect statistical fluctuations in tidal properties, as is required to test H1 and H2. Both methods can be applied equally well to either surface elevation (as measured by a tide gauge) or tidal current (as measured by a current meter) records, though the vector nature of the current data changes the analysis details. Analyses of tidal currents discussed below focus on the alongchannel velocity that moves water in and out of the estuary. This component of the current is aligned approximately along a NNW-SSE axis.

5.1. *Harmonic Analysis of Tides*

Harmonic analysis describes observed tides in terms of a set of frequencies known from astronomical considerations. The analysis assigns an amplitude and phase to each frequency so as to minimize errors (defined as the differences between the data and the harmonic description of the data) according to a "least-squares" criterion; i.e., the sum of the square of the errors over the record is minimized. This technique has been in common use for more than a century and is extremely effective in representing tides in areas where astronomical forcing is the only factor causing variations in surface elevation. It maximizes the number of frequencies that are resolved, provides an extremely compact representation of the data, and allows prediction of past and future tides. The weaknesses of this technique are that: a) it presumes that the tides are a "statistically stationary" process, b) it provides no information regarding fluctuations in tidal processes, and c) it does not describe fluctuations in current or surface elevation not driven by the sun and moon (unless these surface fluctuations happen to occur exactly at a tidal frequency). Thus, harmonic analysis presumes that hypothesis H1 and H2 are false and treats the mean-flow effects of interest here as "noise". It is not, therefore, a suitable method for testing these hypotheses.

5.2. *Continuous Wavelet Transform Analysis of Tides*

Analysis of tides using continuous wavelet transforms is a recent development, designed specifically to examine non-stationary tides; i.e., tides where the observed surface motion is the result of atmospheric motion plus other perturbations. It has been used to examine river tides, and even biological processes that exhibit tidal variability (Jay and Flinchem, 1997; Flinchem and Jay, 2000). Its advantages relative to harmonic analysis are (Jay and Flinchem, 1999):

- It makes no assumptions about the types of processes present or the statistical stationarity of the data.
- Rapid changes in tidal properties can be tracked, even when these changes occur over a few days. This is important in capturing the transient effects of storms or rapid changes in MBPP intake volume.
- It quantifies a fuller range of frequencies, limited only by the length of the record and the time resolution of the data. The wavelet method uses astronomical information to define frequencies, but unlike harmonic analysis, the filter scheme is set up to capture non-tidal variance as well.
- The wavelet method is stable in the sense that, for short records, the results are less dependent on the character of the data and the details of the analysis than for harmonic analysis.

Not surprisingly, there are also limitations implied by the use of wavelet transform tidal analysis. The most important in the present instance is that the number of frequencies that can be resolved is limited by the very short analysis windows used – a wavelet analysis determines only tidal species, not the constituents by which these species may be represented. A short analysis window is dictated by the need to resolve day-to-day changes in tidal processes. Since, however, the wavelet analysis is designed for use only in cases where the tides are non-stationary (which removes the physical meaning of tidal constituents), this is not a fundamental limitation. The wavelet analysis' ability to predict future tides is also limited by the relatively small number of frequencies used. If the tides are truly non-stationary, this is not really a disadvantage either – no simple method will yield meaningful predictions.

5.3. _Spatial and Temporal Patterns_

It is also important to explain how spatial and temporal patterns of tidal properties are to be resolved. For any location, the output from a wavelet tidal analysis of surface elevation time series is a set of amplitudes and phases representing the behavior of each tidal species as a function of time. Although it is possible to obtain an analysis output for each frequency corresponding to the time of each input data point, it is more convenient to obtain outputs of all parameters at intervals of several hours; a 6-hr interval was employed in this study. In order to search for small changes in the tidal dynamics of Morro Bay related to fluctuating mean flows, it is necessary first to remove the much larger tidal monthly or neap-spring variations in tidal properties. This can be achieved using data from a reference station. Usually, the reference station is a nearby tide gauge on the open coast; sometimes a local station in the estuary is used. In either case, the tidal wave impedance for the two stations (the estuarine station and the reference station) is calculated as a function of time. This complex impedance at any time is the ratio at that time of the complex numbers representing the amplitude and phase of each tidal species at the estuarine and coastal stations. For practical data analysis, the impedance time series for each species is resolved into two components: a) an amplitude ratio time series (the amplitude at the estuarine station divided by the amplitude at a reference station), and b) a phase-difference time series (the phase of the estuarine station minus that at the coastal station). To bring spatial variations of tidal dynamics within Morro Bay, it is also useful to calculate an impedance between the two stations for which data are available in the bay, using a ratio of the more landward station to the more seaward station.

The impedance for the major tidal species D_1 and D_2 is calculated in a direct way; e.g., as the ratio of D_2 at MBN or MBS to D_2 for a reference station, usually Port San Luis (PSL) for tidal elevation or Los Angeles for currents. For the comparison within the bay, D_2 for MBN is compared to D_2 for MBS. An indirect calculation of impedance is used for the overtides, because overtides are non-linear tidal species created by specific interactions of the major tidal species D_1 and D_2. In calculation of their impedance, therefore, the reference station is used differently than for the major tidal species D_1 and D_2. Since D_4 is created by the quadratic interaction of D_2 with itself, the D_4 impedance amplitude is calculated as the ratio of D_4 amplitude in the bay (at MBN or MBS) to the square of D_2 amplitude at a reference station. The D_4 phase difference is the D_4

phase minus twice the D_2 phase. This approach reconciles the different time bases of the phase calculation at the two different frequencies; i.e., 360° in phase is 12.42 hr for D_2, but only 6.21 hours for D_4. For D_6, the impedance amplitude is calculated as the ratio of D_6 amplitude in the bay (at MBN or MBS) to the cube of D_2 amplitude at a reference station. The D_6 phase difference is the D_6 phase minus three times the D_2 phase.

Two other types of impedance plots were also employed, distinguished by the choice of reference station. For the tidal elevation data set, there were two stations located in the bay. Given multiple stations, spatial differences in tidal amplification, distortion and energy loss can be detected by calculating an impedance ratio of the more landward station (MBS) relative to the more seaward station (MBN), instead of to the coastal reference station. In this case, the overtide comparison for stations MBS and MBN within the bay was carried out directly in terms of the ratio of amplitudes and phase differences for MBS and MBN. Thus, a ratio of D_4 amplitudes at MBS and MBN was calculated without use of the reference station amplitude. The ratio of overtide amplitudes at the tide and current stations in the interior of the bay relative to local D_2 at the same station (instead of D_2 at a more seaward station) was also a useful parameter for detecting frictional modification of the tide. This utility arises from the fact that overtide energy comes at the expense of energy in the main (D_1 and D_2) tidal species. Thus, an increase in D_4 or D_6 will typically coincide with a decrease in D_2. When this sort of variation occurs, the change in the local ratio of D_4 to D_2^2 (or D_6 to local D_2^3) will be larger than the change in the ratio of D_4 to reference station D_2^2 (or D_6 to reference D_2^3).

Finally, it should be noted that all phases have an inherent ambiguity of 360 ° in phase; i.e., 360° may be added to or subtracted from any phase without changing the mathematical meaning of the phase, though the appearance and interpretation of the resulting phase plot may be altered. An attempt has been made to "unwrap" the phase in such a way as to produce the most compact form of phase variation, but this approach still does not always result in a phase plot with a clear interpretation.

5.4. *Definition and Estimation of the Tidal Prism*

Implicit in the analysis that follows is the idea that the tidal prism and tidal range are closely related. In fact, tidal prism volume V_P increases directly with tidal range – this can be demonstrated by integration of an equation expressing conservation of fluid mass. Thus for a rising tide:

$$V_P = \int_0^L \left(b\,h\right)\Big|_{t=\frac{T}{2}} - \left(b\,h\right)\Big|_{t=0} dx \tag{2}$$

where: x is distance along the estuary, t is time, b is the width of the estuary (which varies with x and t), h is the surface elevation (which also varies with x and t), L is the length of the estuary, and $T/2$ is the length of time between low water and the following high water, and T is the tidal period. This relationship says that the tidal prism is the volume between the high and low water surface levels, determined from the product of estuary height and width, integrated over the length of the system. Eq. 2 also suggests, however, that there is not a unique relationship between tidal range and tidal prism, because the width of the bay increases greatly at higher tidal elevation. Thus, for example, the tidal prism for a 5 ft rise between 1 ft and 6 ft above MLLW will be larger than that for a rise between MLLW and 5 ft above MLLW. Figure 5.1 (top) shows the relationship between estimated tidal prism and tidal range at station MBS, for the March-April 1998 period. This tidal prism was estimated under the assumption that the entire bay has a tidal range the same as station MBS, using the volume vs. elevation curve (Figure 5.1, bottom). As noted below there are some variations of range with position, but station MBS is likely representative for the interior of the bay. Figure 5.1 suggests that: a), in practice, the variation of tidal prism for any given range is small relative to the variation with range, and b) tidal range increases almost linearly with tidal range, despite the non-linear elevation vs. volume curve.

Tidal range is calculated directly from the tidal height data rather than from tidal analysis results, so its determination does not depend on the details of any particular tidal analysis method. The tidal range used here is a daily greater tidal range (difference between the higher high and lower low waters), the long term average of which approximates the greater diurnal tidal range reported in tide tables as the difference between MHHW and MLLW. This tidal range also defines the tidal prism (the volume between the higher high and lower low water planes). Tidal range is calculated as a continuous function of time. At any point in time t, the tidal range is the difference between the largest and smallest hourly tidal elevations in a window extending from points $t - n$ to $t + n$ (n an integer). This moving window always contains an odd number of data points. The tidal day has an average length of 24.84 hr, so the minimum useful value for n for hourly data is $n = 12$; i.e., a window with 25 hourly observations. However, tidal variability and atmospheric perturbations cause some tidal days to be longer than 25 hr. Therefore, $n = 13$ (a 27 hr window) has been used here. In fact, the calculated tidal range changes very little for values of n from 12 to 14.

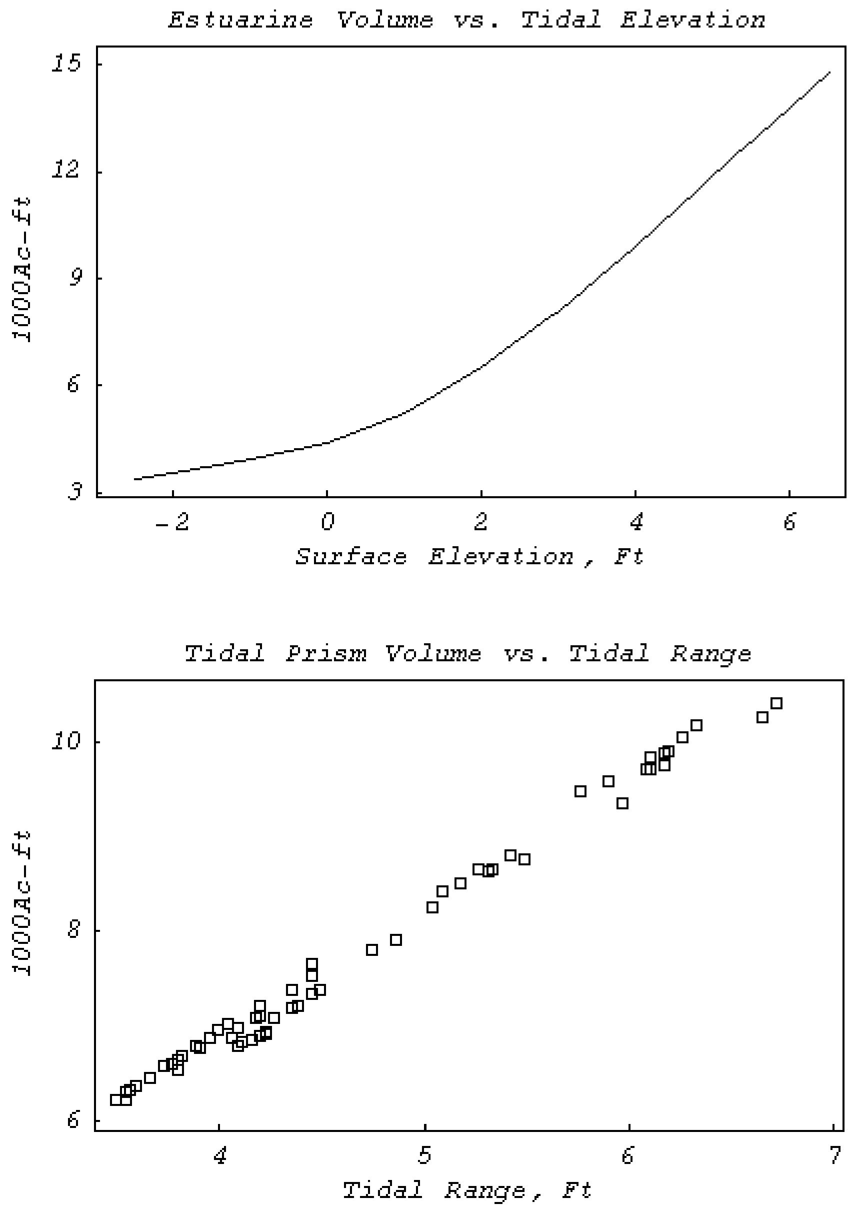


***Figure 5.1**: Morro Bay volume vs. tidal elevation (top) and greater daily tidal prism as a function of tidal range (bottom). Bay volumes above 5.4 ft are extrapolated from data in Tetra Tech (1999). Tidal prism is the volume between HHW and LLW, determined at 6-hr intervals; see text for details.*

6. Data Sets

The analyses described in this report consider two aspects of the tides: a) the rise and fall of the tide, as measured by surface elevation records, and b) the tidal exchange, as measured by a current meter. There is, moreover, a direct linear relationship between tidal range and tidal prism volume – any change in one implies a change in the other. Thus, a positive result for H1 or H2 in analyses of either tidal elevation or tidal currents implies a positive result for the other variable.

The Morro Bay tidal elevation data employed here were collected at two stations by Tetra Tech between 9 March and 10 April 1998, during an El Nino winter with high rainfall (Figures 2.1 and 6.1; Tetra Tech, 1999). Of these two stations, MBN is near the mouth of the bay and the Morro Bay Power Plant. Station MBS is in mid-bay near the river deltas. These two stations are well situated to capture spatial variations of tidal properties in the bay. The sampling period provides both fluctuating river flow related to the passage of several storms (Figure 6.2) and a variable MBPP intake flow volume (Figure 6.3); however, the plant operated to some degree during the entire period, so the MBPP intake volume never drops to zero. As a result of the unusually high river flow, salinities in the bay were likely their typical values for the spring season. The storms also brought sporadically strong winds, which likely perturbed the surface elevation of the bay on occasion. Neither winds nor changes in salinity are analyzed here, and they may contribute to the background noise of the results.

The current meter data analyzed here were collected at a single station near Fairbank Point by PGE between November 1995 and January 1997 (Figure 6.4). The current meter employed was an Interocean S4 located at mid-depth on the West side of the channel at Fairbank. There were two deployments, yielding almost 10 mo of data over a 15-mo period; there is a gap of several months between deployments in the middle of the record. This covers a substantial river flow range (1.1 to 457 ft^3s^{-1} or 0.03 to 4.6 % of the tidal prism; Figure 6.5) and almost the entire range of MBPP intake flow levels (~50 to 612 MGD or 0.6 to 8.8 % of the tidal prism, Figure 6.6). MBPP intake flow is not available, however, for November-December 1995. The deployment location for the current meter is ideal for determining whether there are any effects of the MBPP on the more landward portions of the bay. The S4 current meter that collected the data was also equipped with temperature and conductivity sensors. Temperature, salinity and density records are, therefore, available for the observation period, but have not been analyzed in detail. Examination of the data suggests that the mean flow (after removing the tides by averaging) at this current meter was generally northward toward the mouth of the estuary, whereas one would typically expect landward flow (to the south) at depth in an estuarine channel. The fact that landward flow was not observed through most of the record is interesting. This absence may reflect: a) the weakness of the two-layer flow (caused by weak river flow and small density differences within the estuary), b) the existence of an inverse estuarine circulation with landward flow at the surface (caused by strong evaporation during dry periods), or c) lateral differences in mean flow patterns related to the shape and curvature of the channel. Moreover, the river flow was very small during most of the record, so that density-driven circulation (either normal or inverse) would have been very weak anyway. Therefore, small differences in flow predominance throughout the cross-section could change the direction of the mean flow at the location of the meter. Moreover, landward near-bed flow of up to 0.1 ft s^{-1} did occur during the high river flow events in February 1996 and January 1997. That is, the strong horizontal density gradient occasioned by the high river flow drove a two-layer estuarine circulation, with the river inflow moving out at the surface and denser water moving landward closer to the bed.

Coastal tidal data for Los Angeles, Port San Luis, and Monterey for 1995 to 1998 were obtained from the National Ocean Survey (*http://co-ops.nos.noaa.gov/active_ stations.shtml*). Comparison of the harmonic tidal constituents for these three coastal stations suggests that their tidal properties are quite similar. Port San Luis (the closest coastal station to Morro Bay) was used as a reference station for calculation of the amplitude ratios and phase differences in analyses of the 1998 tidal elevation data. The relevant section of Port San Luis (PSL) data are shown in Figure 6.1. Data for Port San Luis were missing, however, for November-December 1995, so Los Angeles tidal elevation was used as a reference station for analyses of the 1995-98 PG&E current meter data (Figure 6.7).

It was also necessary to deal with the disparate time resolutions of the data sets employed, and define a common time interval for tests of the two hypotheses. The two Morro Bay tide gauges collected data as 10 min averages. The PG&E current meter collected 10 min of data every hour. The NOAA data for Port San Luis were collected as 6 min averages, with subsequent averaging by NOAA to one hour. The Morro Bay tide data were, therefore, decimated to hourly intervals, a customary time resolution for tidal analysis. In contrast to the high resolution of the tidal data, MBPP intake and tributary inflow data were available only on a daily basis. A common time base of 6 hr was established for all mean flow variables and analyses of tidal properties by: a) cubic spline interpolation of the MBPP intake and river inflow data at 6 hr intervals, and b) calculation of wavelet tidal analysis outputs at 6 hr intervals.

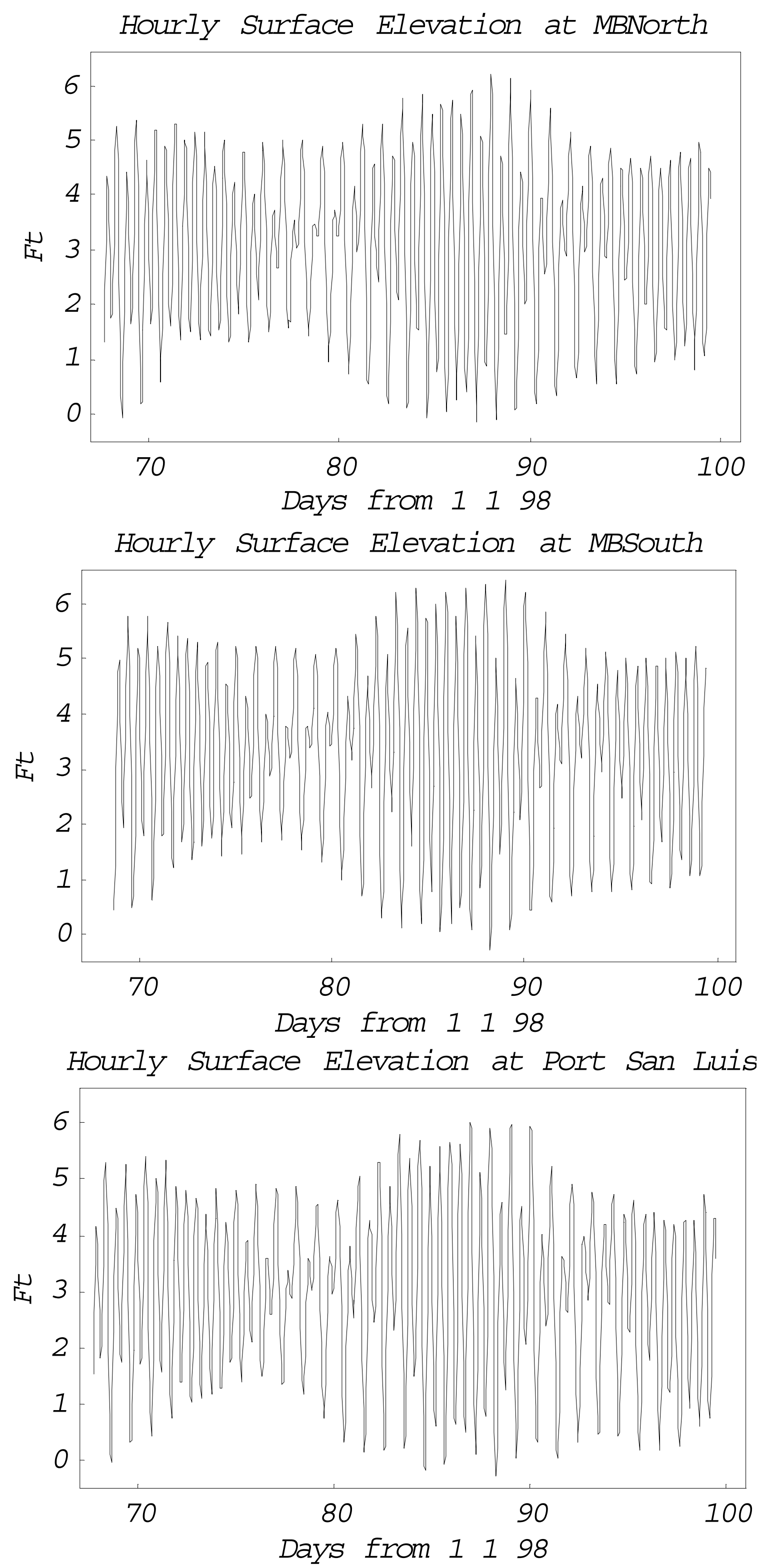
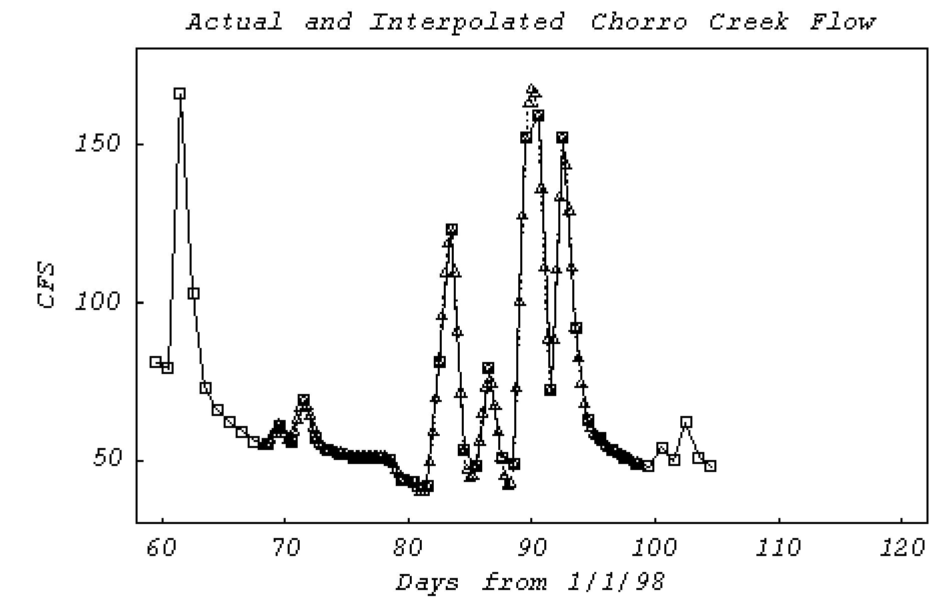


Figure 6.1*: 1998 hourly surface elevation time series for stations MBN (near the MBPP intake), MBS (in mid-bay) and the reference station at Port San Luis (PSL) for ~d 67-99.*



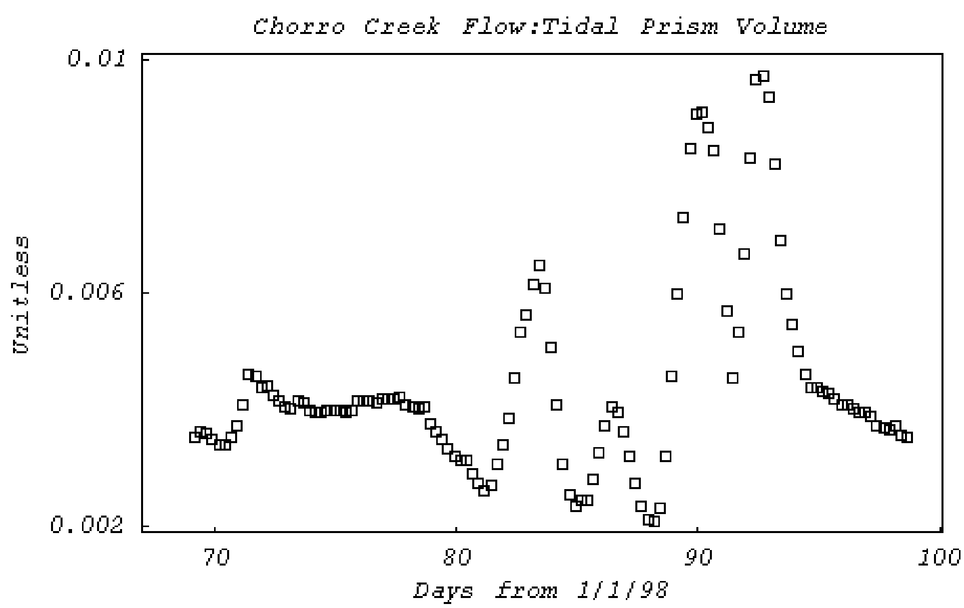
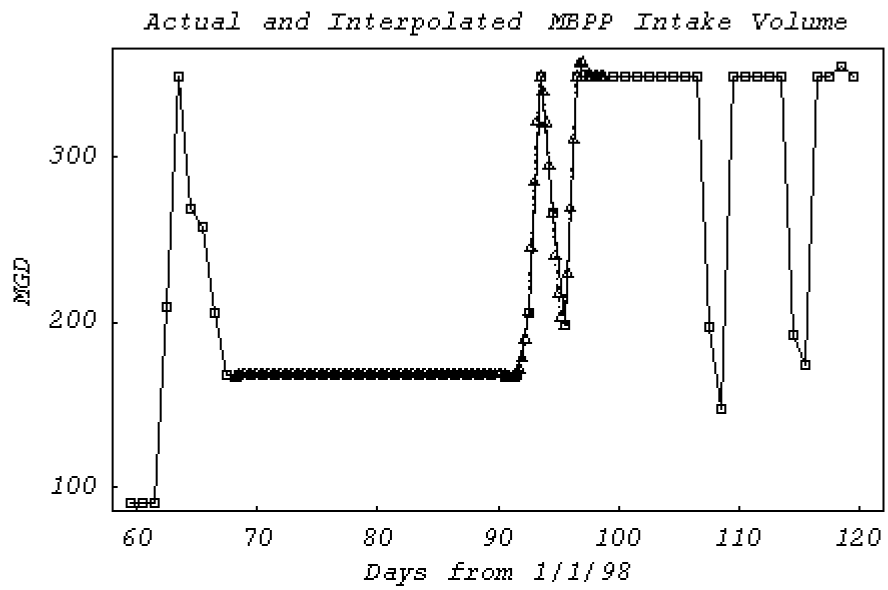


Figure 6.2*: Above: daily river-flow time-series for Chorro Creek* (*), and the 6-hourly interpolated version used in the analyses* ([1]) *of the 1998 Tetra tech data. No river-flow data are available after the middle of March. Below: daily river-flow time-series for Chorro Creek expressed as a function of daily tidal prism.*



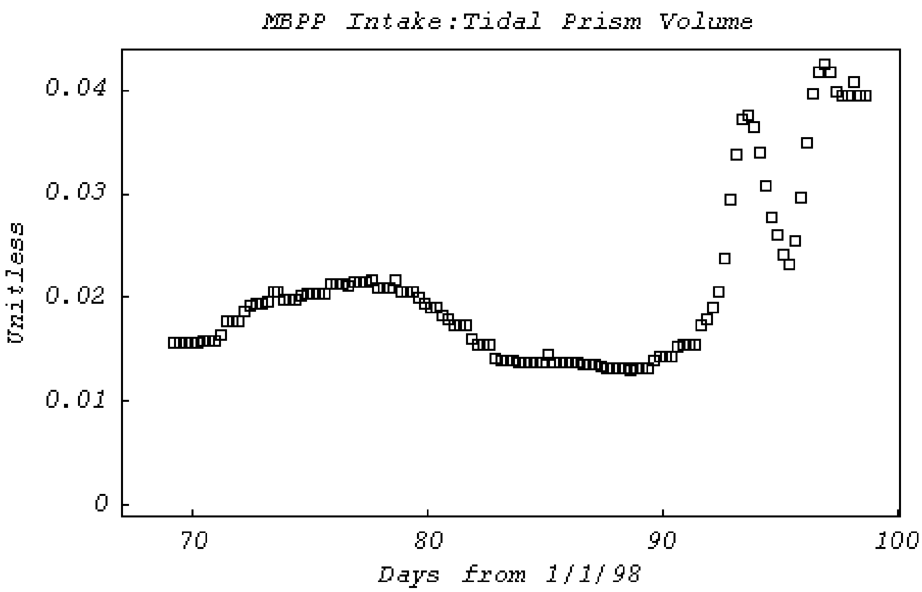


Figure 6.3*: Top: Daily Morro Bay Power Plant (MBPP) intake flow, ( ), and the 6-hourly interpolated version used in the analyses ([1]) of the 1998 Tetra Tech data. Bottom: interpolated Morro Bay Power Plant (MBPP) intake flow expressed as a fraction of the tidal prism. Note that the Tetra Tech data are available only for ~d 67-97.*

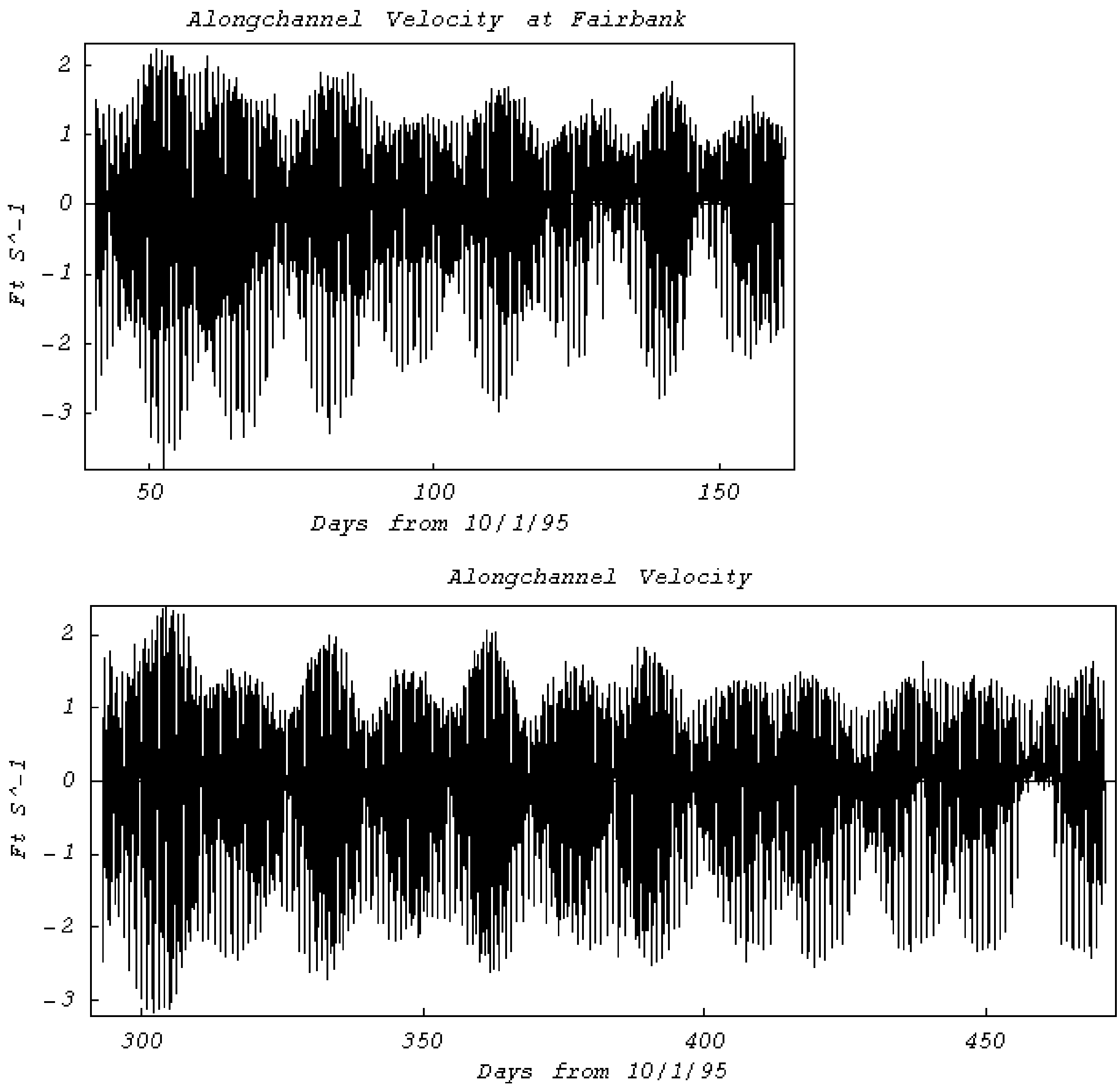


Figure 6.4: *Alongchannel currents in ft s^{-1}, calculated from S4 current meter data collected by PG&E during 1995-1997. There was a gap of ~4 mo. between the first deployment (top) and the second deployment (bottom). Time on the x-axis is in days from 10/1/95. Positive values are landward, toward back bay, in the direction of 166° T.*

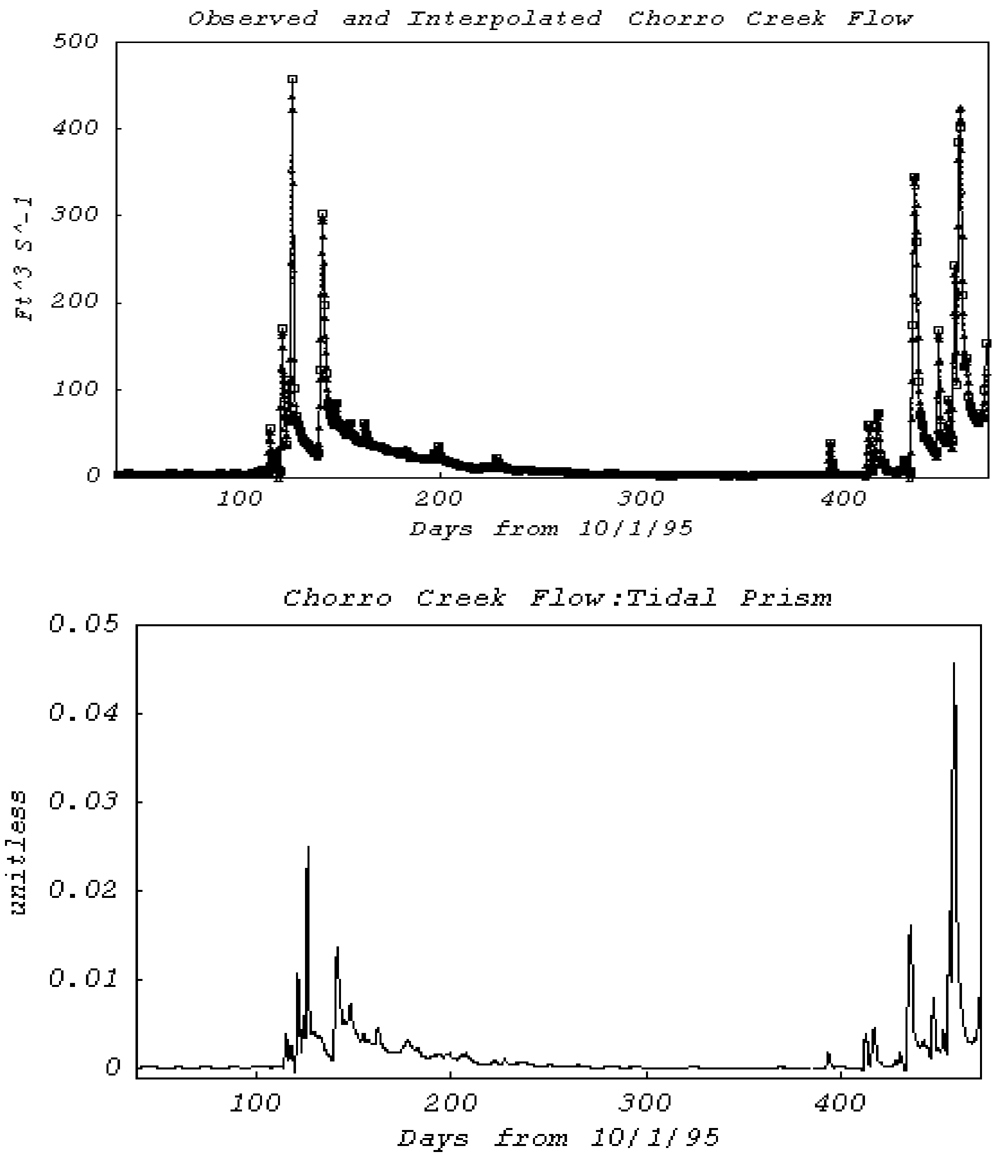
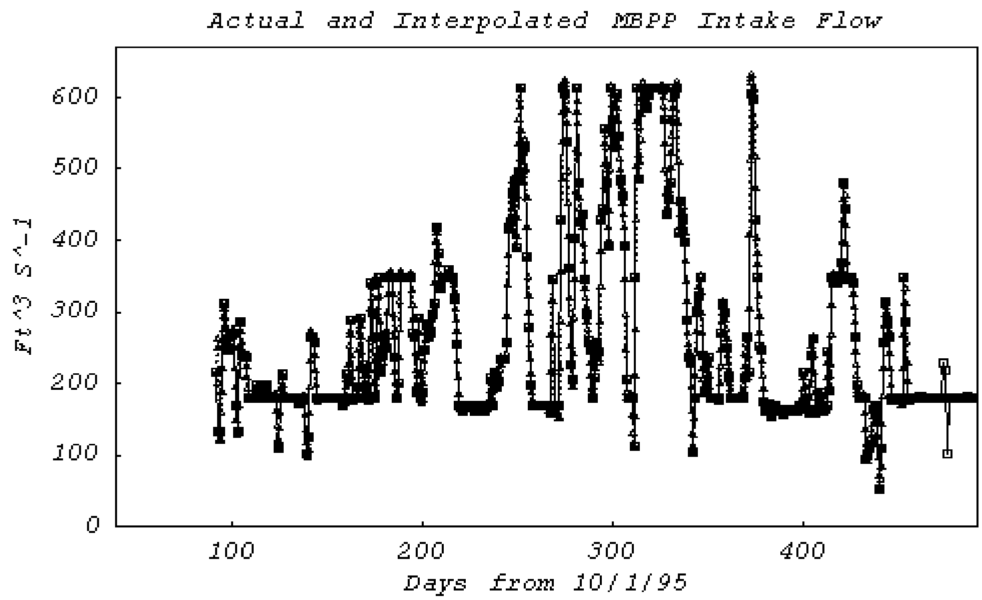


***Figure 6.5**: Above: daily river flow time series for Chorro Creek ( ), and the 6-hourly interpolated version used in the analyses ([1]) of the 1995-97 PG&E current meter data. A missing section of river flow data in 1995 was interpolated from a nearby gauge; flows were uniformly low during this period. Below: daily river flow time series for Chorro Creek expressed as a function of daily tidal prism.*



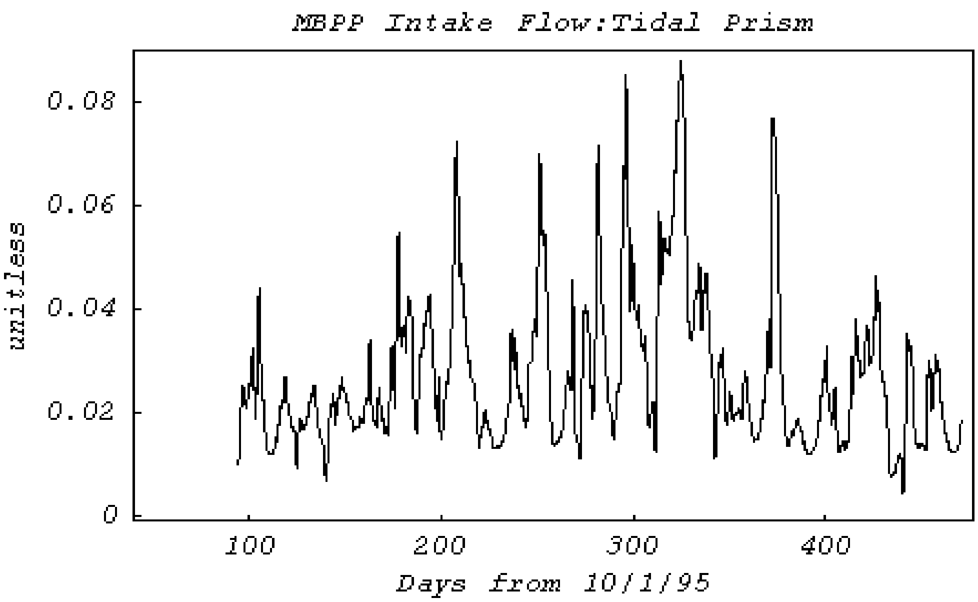
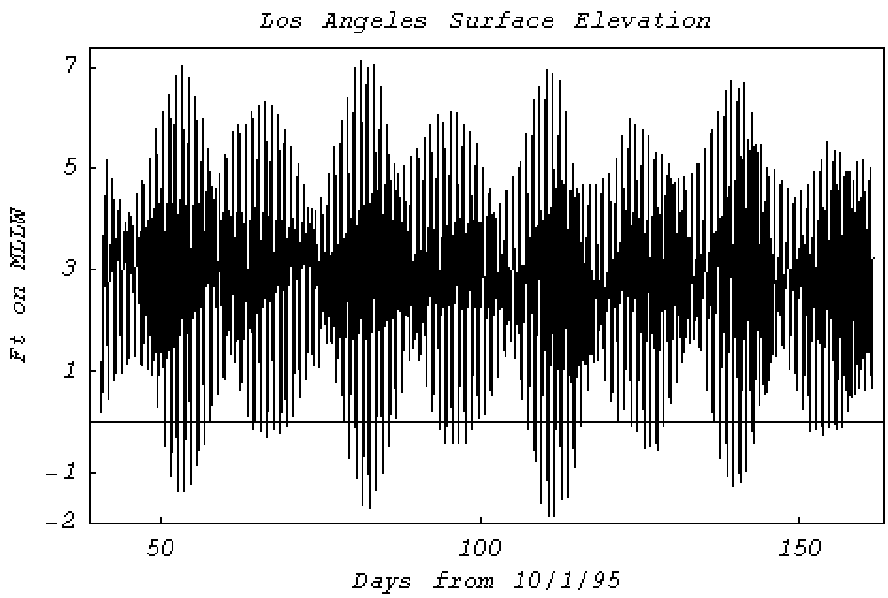


Figure 6.6*: Above: Daily Morro Bay Power Plant (MBPP) intake flow, (   ), and the 6-hourly interpolated version used in the analyses ([1]) of the 1995-1997 PG&E current meter data. Below: interpolated Morro Bay Power Plant (MBPP) intake flow expressed as a fraction of the tidal prism.*



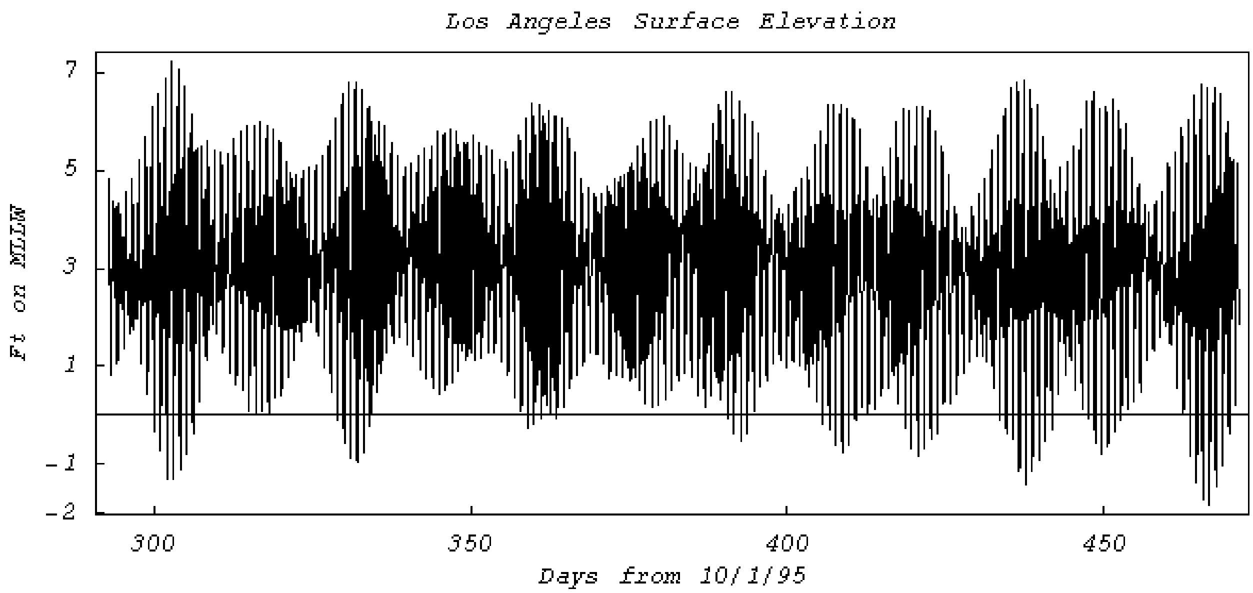


Figure 6.7: *Surface elevation data (obtained from the National Ocean Survey (http://co-ops. nos.noaa.gov/active_ stations.shtml) for (above) the first and (below) the second PG&E current meter deployment. Time in days from 10/1/95 is on the x-axis; elevation in ft relative to MLLW is on the y-axis.*

7. Results

7.1. *Hypothesis H1*

The tidal exchange and tidal prism of Morro Bay are quantities of fundamental ecological importance. Therefore, hypothesis H1 states that: "*The daily tidal exchange and tidal prism of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow*". A positive result for H1 with regard to the MBPP intake flow would suggest that the MBPP has substantial effects on tidal processes and circulation in the interior of Morro Bay. This positive result might then suggest that there are also impacts on sediment transport and shoaling in the interior of the bay. A negative result here suggests (subject to confirmation through a negative result for the major tidal species in H2) that there are no tidal circulation impacts of the MBPP on the interior of the bay. Because tides provide most of the energy for sediment transport in the system, a negative result for the MBPP intake flow for H1 suggests that there are no significant physical impacts of the intake flow on the interior of the bay. Hypothesis H2, discussed below, investigates the effects of mean flow on individual tidal species, and validates the method tested here.

River flow is, aside from the tidal circulation, the other major process in the bay responsible for circulation processes. River flow creates a mean flow through a much larger part of the bay than is the case for the MBPP intake flow, so it should be more effective (per unit flow volume) than the MBPP intake flow in altering the tides and mean surface elevation. A negative result in H1 for the river flow likely means that the data set does not include any high-flow events. Considering results for other estuaries, effects of river flow on the tidal prism (i.e., a positive result for H2) are expected for river flow at least at the 2 to 5 yr event levels, if not at lower levels. These flows are 1,560 to 5,154 cfs (Tetra Tech, 1998) or ~10 to 33% of the mean greater daily tidal flux, respectively. Because of the greater sensitivity of the smaller tidal constituents, a positive result for H2 may occur for even lower flow levels.

Tidal range and tidal exchange are directly related through conservation of mass. That is, an increase in tidal range from one day to the next implies an increase in tidal exchange exactly sufficient to fill and empty the increased tidal prism associated with the larger tidal range. In principle, therefore, H1 can be tested equally well using tidal elevation data (from which tidal range is inferred) or current meter data (measuring tidal exchange). In practice, however, there is no simple, commonly accepted metric equivalent to tidal range that can be used with tidal currents. While one can note the range of current values over a day, the presence of a mean flow, the higher noise levels, and the vertical variability of tidal currents often render this calculation less than satisfactory in practice. Thus, H1 is tested using tidal elevation data only. The equivalence (through the mass conservation principle) of tidal range and tidal exchange means, however, that results relative to H1 for tidal range also apply to tidal exchange.

The effects of the mean flows (MBPP intake flow and river flow) on tidal range are tested by examining tidal ranges (Figure 7.1) and tidal range ratios (Figure 7.2) for the two stations in the bay (MBN and MBS relative to Port San Luis or PSL). A tidal range ratio between MBS and MBN was also used to examine any possible influence of mean flows on amplification of the tide inside Morro Bay (Figure 7.2). Scatterplots of the tidal range ratios against non-dimensionalized mean flow volume and river flow volume are used to assess impacts, if any. Because tidal prism is calculated directly from observations without use of any tidal analysis method, results for H1 do not depend on the details of any tidal analysis method. The results for tidal range are much more scattered, however, than the results for H2 below, where harmonic analysis has been used. This occurs because the tidal range calculation includes changes in elevation caused by winds, atmospheric pressure and other non-tidal processes. These influences are largely excluded by the tidal analysis, which focuses solely on the tidal response of the system.

7.1.1. *MBPP Intake flow and Tidal Range*

One way to measure the strength of the MBPP intake flow is as a ratio to the actual tidal prism for each day of operation. The minimum possible value of this ratio is clearly zero, when the plant is not in operation. The maximum ratio of around 9% corresponds to full operation and the weakest possible neap tide. The total range of MBPP intake flow during the Tetra Tech sampling period was from 1.3 – 4.2% of the tidal prism (Figure 6.3). This range covers from low plant operation levels up to about half of the total possible maximum MBPP intake flow. During most of the sampling period, MBPP intake flow was about 170 MGD, yielding a ratio to tidal prism of ~1.3 - 2.3% (Figure 6.3), and the largest variation of tidal range responses occurred at this intake flow level (Figure 7.3). There is, moreover, no trend toward higher or lower tidal ranges as the MBPP intake flow increased relative to tidal prism. There is also no indication that tidal amplification within the bay (the MBS:MBN tidal range ratio) is a function of MBPP intake flow. This is clearly a negative result for H1 with regard to the effects of MBPP intake flow on the tidal prism and tidal exchange. Effects on sediment transport in the interior of the bay are, therefore, very unlikely. This result does not necessarily rule out, however, subtler changes to individual tidal species caused by the MBPP intake flow, considered under H2a.

7.1.2. *River Flow and Tidal Range*

There were no major flow events during the March-April 1998 Tetra Tech sampling period analyzed here. The total range of Chorro Creek inflow during the period was 42 to 166 cfs, or 0.2 to 1% of the tidal prism (Figure 6.2), considerably smaller than the MBPP intake flow. It is not surprising that no effects on the tidal range can be detected (Figure 7.4). Larger river flows do, however, produce measurable effects, as the results for the PGE current meter data demonstrate (Section 7.3).

7.1.3. *Summary for Hypothesis H1*

Results for H1 were negative, for both MBPP intake flow and river inflow. MBPP intake flow varied from 170 to 360 MGD during the March-April 1998 period during which the Tetra Tech tidal elevation data were collected. This intake flow range corresponds to a range in the ratio of intake flow to tidal prism of ~1.3 to 4.2%. The total possible range of the ratio of intake flow to tidal prism is zero (no plant operation) to ~9% (full operation during the weakest neap tide). The available range of plant operation did not produce any detectable perturbations to the tidal prism at station MBN (near the MBPP plant) or at station MBS (in the interior of the bay). The ratio of tidal range at station MBS to that at MBN was also unaffected. It is unlikely that analyses of data from another period that covered the full operation range (from 0 to 9%) would produce any different result. River flow into Morro Bay during the March-April 1998 period was only ~0.02 to 1% of the tidal prism. This is not high enough to produce any real perturbation of the tides. Higher river flows do perturb the tidal range, thereby likely affecting sediment transport.

7.2. <u>*Tidal Analysis Results*</u>

7.2.1. *Tidal Harmonic Analysis*

Harmonic analysis provides a detailed picture of the average frequency content of a surface elevation or current record, under the assumption that the tides are stationary. Harmonic analysis results for Port San Luis (station PSL) and the two stations in Morro Bay are listed in Table 7.1 (1998 data set). Tables 7.2 and 7.3 summarize tidal datum levels and ranges estimated from the harmonic constants. Results for MBN and MBS are based on the month of available data. The PSL results are reported in two forms: a) an analysis of the data for the entire year of 1998, and b) an analysis for the one month period for which data are available at MBN and MBS. Although the one-year record provides more precise knowledge of tides at PSL, comparisons between stations must should be based on similar record lengths and time periods; i.e., on the one-month analyses for the three stations. All records were sufficient to resolve at least the three largest diurnal (D_1) constituents, the four largest semidiurnal (D_2) constituents[3], and at least one constituent for the overtide species D_3 (constituent M_3), D_4 (constituent M_4), D_6 (constituent M_6), and D_8 (constituent M_8). Analyses of one year of data (1998) from Monterey and Los Angeles indicate that the results obtained for Port San Luis are representative.

The harmonic analyses of tidal elevation data show that:

- The semidiurnal tide is larger than the diurnal tide, as is typical of most of the West Coast of the US. The semidiurnal constituent M_2 (the twice-daily tide driven by gravitational attraction of the moon) is the largest constituent, followed by the diurnal constituent K_1.
- The tidal constituents of the basic diurnal and semidiurnal tidal species show, as expected, little variation amongst the three stations.
- There is a slight increase of the semidiurnal tide in the basin, evident at MBS, the station farthest from the ocean. There is a small decrease in the diurnal tide at station MBS, relative

[3] One of the three diurnal and one of the four semidiurnal constituents resolved in the analyses of the one-month records for stations PSL, MBN and MBS required use of a technique called "inference". Inference employs a longer analysis (the one-year record for PSL, in the present case) to increase the resolution of the one-month analyses. Minor differences between the one-year analysis and one-month analysis for PSL arise from the difference in record length, but these are unimportant in the present context.

to station MBN. Thus, the ratio of the sum of the three largest semidiurnal constituents to the sum of the three largest diurnals is 1.05 at MBN and 1.11 at MBS.

- Tidal ranges increase from the coast toward the head of the bay by 0.15- 0.2 ft, indicative of slight amplification by the topography. The datum levels reported in Table 7.2 for MBN (near the mouth of the bay) are consistent with previous estimates in other studies.

- The largest difference between the stations in the bay is the greater amplitude of the overtide constituents M_6 and M_8 inside the bay, especially at station MBS, farthest from the ocean. Thus, M_6 is ~17 times as large at MBS as at PSL. M_8 is 2-6 times larger inside the bay.

- As predicted above, the strongest overtide is the six-diurnal overtide (constituent M_6), which is very small at PSL and grows in a landward direction. This overtide is the result of bed friction in the shallow water of Morro Bay. The terdiurnal (D_3) and quarterdiurnal (D_4) overtides (constituents M_3 and M_4, respectively), which result from distortion of the tidal wave in shallow water, are also larger in the bay by a factor of 2 to 5.

- The strong temporal variability of very small overtides (M6 and M8 at PSL) suggest either that they are strongly variable in time or are not accurately determined. Attention to the spatial and temporal patterns of theses overtides is, therefore, important.

Harmonic analysis of the PG&E tidal current data (Table 7.4) provides additional information regarding tidal processes. Important features suggested by Table 7.4 and the data include:

- Currents near Fairbank are fairly strong, up to ~2 ft s^{-1} on flood (to the south with positive values in Figure 6.4) and ~3 ft s^{-1} on ebb (to the north with negative values in Figure 6.4). The difference between the flood and ebb currents is partly accounted for by river flow, but wave distortion effects and flood-ebb differences in the lateral distribution are also involved.

- Although maximum currents are strongly seaward (ebb-oriented), the mean flow through most of the current record is weak and variable. The relative strengths of maximum flood and ebb currents do not predict the mean flow, because there is a substantial degree of distortion of the currents by the presence of tidal flats. Floods are relatively long and slow, whereas ebbs are short and fast. Thus the difference between peak flood and ebb currents is larger than that between the average flood and average ebb currents. The variability of the mean flow is also related to the presence or absence of mean flows generated by winds and the internal density field of the estuary.

- During the periods of strongest river in flow (~d 120-150 and 420-440), the mean flow is actually landward at this cross-section. This likely occurs because the meter is deep enough in the flow to be in the landward-flowing bottom layer during the high-flow periods when estuarine circulation is strong. It is possible that a weak negative estuarine circulation contributes to the net outflow during December 1995, before the onset of winter rains.

- The current meter data provide ambiguous information regarding sediment transport patterns in the system. On the one hand, the ebb dominance of maximum currents suggests that sediment supplied by tributary streams during periods of high river flow can be exported from this part of the estuary during river flow events. On the other hand, the landward mean flow during the same periods is conducive to retention of sediment. Coarser material is likely to move in the direction of maximum current, whereas fine material may also be influenced by the mean flow.

- The deeply scoured channel at Fairbank implies that tidal currents are stronger there than at most other locations in the bay. This is especially true relative to back bay, where tidal currents are clearly weak.

- Tidal currents are more irregular than tidal elevations, because of the influence of river inflow, winds and natural variability within any channel cross-section. Most of these features are much less prominent in a tidal record than is the case with current meter data.

- Semidiurnal (D_2) currents at Fairbank are considerably stronger than diurnal (D_1) currents. The ratio of the three largest D_2 current constituents to the three largest D_1 current constituents in Table 7.4 is 1.86, even though the corresponding ratio for tidal heights is only ~1.1. This is an expected result. The D_2 tidal cycle lasts only about half as long as the D_1 tidal cycle. Thus, any given D_2 tidal elevation amplitude causes about twice the current as the same D_2 tidal elevation amplitude, because the tidal exchange occurs in half the time.

- Overtide current amplitudes are stronger (relative to the D_2 current amplitude) than is the case in the tidal elevation record. This result is also expected, and is related to complex tidal variations in the distribution of flow within the Fairbank cross-section. The cross-sectionally averaged currents likely show less overtide variability than does the current at any one location in the section. The surface elevation record reflects sectionally-averaged currents.

- Although lateral currents were not analyzed in detail here, the lateral current record also contains useful information. Lateral currents at Fairbank are mostly overtides related to the fact that the channel near Fairbank is slightly curved. Surface elevation on the outside of the curve (on the West side of the channel) will be slightly higher on both flood and ebb. This lateral motion at twice the basic tidal frequency creates overtide currents. Because of the role of lateral currents, the ratio of minor to major axis amplitudes is larger for the overtides than for the D_1 and D_2 constituents.

- There are also likely vertical variations in current structure that are related to changes in river flow and salinity. These cannot be resolved with data from a single current meter.

In summary, the tidal records for the Morro Bay area are typical of those for regions with narrow continental shelves. The basic D_1 and D_2 tidal species show only weak spatial variability. Overtides grow inside the bay and are most prominent at the one station located well inside of Morro Bay (MBS). There is a slight amplification of the tide from the coast to the head of the bay. Tidal currents in the bay are driven by changes in surface elevation. The tidal current patterns revealed by tidal analysis are, therefore, consistent with the results for analysis of tidal elevation. The most conspicuous differences between the current and elevation records are: a) the stronger overtides in the current record, and b) the creation of lateral (cross-channel) flows by channel curvature; this process could not be detected in the available elevation records.

Table 7.1: Tidal Harmonic Analysis Results for the 1998 Tidal Height Data

Constituent	Port San Luis§ – (PSL) – 1 Year		Port San Luis§ (PSL) – 1 Month		Morro Bay North* (MBN) 1 Month		Morro Bay South* (MBS) 1 Month	
	Amp, m	Phase, °	Amp, m	Phase, °	Amp, m	Phase, °	Amp, m	Phase, °
Q_1	0.040	194	0.049	193	0.051	194	0.052	207
O_1	0.222	199	0.219	195	0.237	217	0.222	206
P_1	0.110	212	0.116	211	0.111‡	215‡	0.111‡	218‡
K_1	0.356	215	0.373	213	0.357	217	0.354	221
N_2	0.115	145	0.131	147	0.112	149	0.134	161
M_2	0.489	168	0.490	167	0.482	174	0.498	182
S_2	0.148	164	0.151	167	0.148	178	0.152	187
K_2	0.044	157	0.045	160	0.045†	171†	0.045†	180†
M_3	0.0025	357	0.0027	10	0.005	47	0.005	56
M_4	0.0024	277	0.0024	255	0.005	29	0.012	131
M_6	0.0002	223	0.0009	268	0.003	153	0.017	130
M_8	0.0007	320	0.0009	332	0.002	207	0.005	87

§ 1998 hourly data provided by the National Ocean Survey
* 1998 hourly data provided by Tetra Tech (Tetra Tech, 1999)
‡ Inferred from K_1, using the Port San Luis 1-year record.
† Inferred from S_2, using the Port San Luis 1-year record.
Tidal amplitude represents the magnitude of the vertical excursion of the water surface level.
Tidal phase is the timing of high water relative to the moon's passage over the Longitude of Morro Bay.

Table 7.2: Datum Levels Estimated from Harmonic Constituents, 1998 Tidal Height Data

Datum Level	Port San Luis (PSL)§ – 1 Year		Port San Luis§ (PSL) – 1 Month		Morro Bay North* (MBN) 1 Month		Morro Bay South* (MBS) 1 Month	
	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
MHHW	5.46	1.665	5.36	1.634	5.28	1.609	5.48	1.671
MHW	4.71	1.436	4.65	1.417	4.58	1.395	4.75	1.449
MLHW	3.96	1.207	3.94	1.200	3.87	1.181	4.03	1.227
MTL	2.83	0.862	2.86	0.873	2.80	0.856	2.91	0.887
MHLW	1.89	0.576	2.15	0.656	2.08	0.635	2.13	0.648
MLW	0.945	0.288	1.08	0.328	1.04	0.317	1.06	0.324
MLLW	0	0	0	0	0	0	0	0

§ 1998 hourly data provided by the National Ocean Survey

* 1998 hourly data provided by Tetra Tech (Tetra Tech, 1999)

Table 7.3: Selected Ranges Estimated from Harmonic Analysis Results, 1998 Height Data

Range	Port San Luis (PSL)[§] – 1 Year		Port San Luis[§] (PSL) – 1 Month		Morro Bay North* (MBN) – 1 Month		Morro Bay South* (MBS) – 1 Month	
	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
MHHW-MLLW	5.46	1.665	5.36	1.634	5.28	1.609	5.45	1.660
MHW-MLW	3.77	1.148	3.57	1.089	3.53	1.077	3.69	1.118
MLHW-MHLW	2.07	0.631	1.78	0.544	1.79	0.546	1.89	0.575
Greater Tropic	6.13	1.869	6.09	1.857	5.96	1.817	6.04	1.842
Lesser Tropic	1.09	0.331	0.850	0.259	0.803	0.245	0.747	0.227

[§] 1998 hourly data provided by the National Ocean Survey
* 1998 hourly data provided by Tetra Tech (Tetra Tech, 1999)

Table 7.4: Tidal Harmonic Analysis Results for the 1995-97 Current Meter Data

Constituent	Current Amplitude , m s^{-1}		Current Amplitude , ft s^{-1}		Current Direction, Deg. True[§]	Current Phase, Degrees*
	Major axis[†]	Minor axis[†]	Major axis[†]	Minor axis[†]		
Q_1	0.011	0.001	0.036	0.003	349	210
O_1	0.081	0.000	0.266	0.000	343	193
P_1	0.051	0.001	0.167	0.003	351	215
K_1	0.171	0.000	0.561	0.000	346	197
N_2	0.083	-0.002	0.272	-0.006	348	21
M_2	0.377	-0.009	1.236	-0.030	345	40
S_2	0.103	0.003	0.338	0.010	346	25
K_2	0.046	0.003	0.151	0.010	349	28
MK_3	0.027	0.002	0.089	0.007	352	138
M_4	0.053	0.002	0.174	0.007	343	43
M_6	0.015	0.001	0.049	0.003	342	167
M_8	0.006	0.001	0.020	0.003	339	271

[§] Current direction is the direction toward which the current is flowing (oceanographic convention).
Tidal amplitude represents the strength of horizontal tidal currents.
* Current phase is the timing of peak current, relative to the moon's passage over the Longitude of Morro Bay.
[†] Because current is a vector, it has an amplitude in a major axis direction and in a minor axis direction, which is normal to the major axis. In the present case, the major axis is aligned along compass direction 166-346 ~ True, the orientation of the channel thalweg.

7.2.2. *Wavelet Tidal Analysis Results*

Continuous wavelet transform tidal analysis provides a continuous output over the period of a tidal record of the variation in amplitude and phase of the major tidal species. Tidal constituents within tidal species are not resolved. In the present case, wavelet tidal analysis is used to investigate possible non-stationary behavior in Morro Bay tides. Figure 7.5a shows amplitude "scaleograms" for tidal elevation data collected at stations Port San Luis (PSL), MBN and MBS. A scaleogram uses color density or shading to indicate variations in amplitude as a function of time (on the horizontal axis) and frequency (on the vertical axis)[4]. A scaleogram is almost like a fingerprint of a tidal record – an enormous amount of information is provided, and each record is slightly different.

These scaleograms suggest the following conclusions:

- The D_1 tidal amplitudes at the three stations are very similar, both in amplitude and in time variations in amplitude. The D_2 tidal amplitudes show a similar spatial consistency.
- The most prominent features of the D_2 tide are spring tides at ~d 70 and 87. Another spring tide at the end of the record cannot be fully resolved. The strength of these spring tides varies because of variations in the distance between the moon and earth.
- The D_1 tide has maxima (related to the declination of the moon's orbit) at ~d 80 and 92.
- Overtides are relatively weak at Port San Luis, slightly larger at MBN, and substantially larger (though still small relative to D_1 and D_2) at station MBS.
- Overtides are strongest on spring tides, as is logical from the fact they are generated in proportion to the square or cube of the amplitudes of the D_1 and D_2 tides. D_6 is the strongest overtide, as suggested already by the harmonic analysis. Maxima in the D_1 tide do not appear to be as effective in generating overtides. This is likely because the primary generation mechanism is bed friction (rather than wave distortion), and D_1 currents are weaker than D_2 currents for any given tidal height amplitude.

[4] Because wavelet analysis uses digital filters to resolve the signals at the various analysis frequencies, the output record is shorter than the input record by half a filter length at the beginning and at the end of the record. Longer filters are required for lower frequencies, thus, the lower the frequency, the more the record is truncated. Phase scaleograms were also calculated and show similar results.

- The Port San Luis record shows energy at a period of 4 d; this signal is found in the Los Angeles record (not shown) as well. It does not penetrate into Morro Bay.

The overall picture provided by the wavelet analysis of tidal elevation data supports that from the harmonic analysis. The most important added information is the close correspondence between spring tides and generation of overtides.

Wavelet analysis also reveals important details of the tidal current record (Figure 6.4). A scaleogram for the alongchannel component of the 1995-97 current meter data is shown in Figure 7.5b.

- Alongchannel D_1 and D_2 tidal currents show regular neap-spring variability that mirrors the tidal forcing at the coastal tidal height reference station, Los Angeles. D_2 tidal currents showed amplitudes of ~0.6 to 2.3 ft s^{-1}. D_1 tidal currents were ~0.1 to 0.85 ft s^{-1}.
- The strongest alongchannel tidal current velocities were observed in November-December 1995 and August 1996; i.e., at the beginning of each of the two deployments. While this pattern could indicate that biofouling affected the current meter data somewhat, S4 current meters are not normally susceptible to biofouling. Moreover, the D_1 and D_2 patterns do not change in a similar manner, which also suggests that biofouling was not a factor.
- Alongchannel overtides were strongest on spring tides. Alongchannel D_3 and D_4 overtide currents reached 0.2 to 0.45 ft s^{-1} and 0.25 to >0.5 ft s^{-1} on spring tides, respectively. Alongchannel D_6 and D_8 overtide currents were not as strong, only about 0.1 to 0.2 ft s^{-1} and 0.1 ft s^{-1} on spring tides, respectively.
- The spectral distribution of tidal energy amongst the alongchannel overtide current species is different than was the case for the tidal elevation data, where the greatest energy was in the D_6 constituent. The fact that there was more current energy in D_3 and D_4 than D_6 reflects two factors: the importance of wave distortion related to the presence of tidal flats, and channel curvature. Tidal flats tend to cause short, sharp ebbs and long, slow floods, as in Figure 6.4. Channel curvature has multiple effects. For example, the maximum flood and ebb currents likely occur in different parts of the channel, because the channel curvature is stronger landward of the station than seaward. This results in a rectification of the current at any given

point in the channel. This rectification both causes the observed ebb-dominance of the mean flows at this station and affects the spectral distribution of overtide energy.

- Across-channel or lateral D_1 and D_2 tidal current amplitudes are weak, less than 0.1 ft s^{-1} on spring tides, with D_2 currents being about twice those for D_1. Interestingly, D_3 and D_4 lateral overtide currents are nearly as strong as the lateral currents for D_1 and D_2. In fact, D_4 lateral currents are larger than D_1 lateral currents. This pattern is typical of overtide generation due to channel curvature.
- Tidal variations in salinity are weak, except just after high river-flow events. When river flow is high, there is a greatly enhanced salinity gradient between Fairbank and the estuary entrance, created by the input of freshwater from Chorro and Los Osos Creeks. When salinity gradients are strong, tidal currents can cause relatively large tidal variations in salinity that are otherwise absent. As expected, these increased tidal variations in salinity are associated with low values of mean (tidally averaged) salinity at Fairbank. Biofouling may have affected salinity values somewhat.

7.3. *Hypothesis H2 – Results for 1998 Surface Elevation Data*

The strategy pursued in this investigation is as follows. Hypothesis H1 was defined to test the effects of mean flows on a quantity of major ecological significance, the tidal prism. Hypothesis H2 addresses the individual tidal processes that collectively create the tidal prism. It states that: "*Specific tidal species and tidal constituents in Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow*". The role of H2 is primarily to support and clarify the results for H1. Any positive result for H1 must be explicable in terms of positive results for at least some of the tidal species in H2. Tidal theory provides, moreover, the knowledge to interpret any positive result for H2 in terms of physical mechanisms. A negative result for H2 would support and extend a negative result for H1, in that the tests employed in H2 are more specific and sensitive than those in H1. A positive result for H2 is possible without a positive result in H1, if the effects on the tides are small and confined to the overtide species. A positive result for H1 without a positive result for H2 would indicate methodological problems. H2 is tested using wavelet tidal analysis results for the major tidal species (D_1 and D_2) and selected overtides (D_4 and D_6), for both surface elevation and currents. The latter provide an especially sensitive test of mean flow effects on tidal propagation in the bay.

Hypothesis H1 can only practically be tested with tidal elevation data, because there is no simple analog to tidal range (calculated from surface elevation) that can be routinely determined for currents. Hypothesis H2 can be tested with either surface elevation or current data. H2 is tested using the 1998 Tetra Tech surface elevation data in this section; analyses of the 1995-96 PG&E current data are described in the following section.

7.3.1. *The Major Tidal Species, D_1 and D_2*

The wavelet analysis provides a time series of amplitudes and phases for all tidal species at each station. Calculation of a complex impedance time series for stations MBN and MBS (using station PSL as a reference) was used to remove tidal monthly variations. The complex impedance was then resolved into an amplitude ratio and phase difference. To examine any changes within the bay, a complex impedance of MBS against MBN was also formed, but this calculation did not provide any new information. Most results shown here for the major tidal species D_1 and D_2 are for the most landward station in Morro Bay (MBS) relative to Port San Luis (PSL); Figures 7.7 - 7.12. This station in mid-bay is emphasized because: a) it is most likely to reveal the effects of a mean flow, b) changes in the interior of the bay that are of primary ecological significance, and c) the results for MBN do not reveal any additional information. These figures show that calculation of the impedance removes most of the neap-spring (and other tidal-monthly) variability. That is, to the degree that the D_1 or D_2 waves impinging on the coast at Morro Bay vary in amplitude in direct proportion to the size of the wave at Port San Luis, then the impedance calculation removes this effect. What this calculation cannot remove is the smaller (non-linear) effects of wave distortion and bed friction in modifying the tidal wave. By removing large, linear effects, the impedance calculation increases the chance that small non-linear effects of mean flows on the tidal regime will be detected.

The D_1 results in Figure 7.6 suggest that the D_1 wave at MBN and MBS is smallest (small impedance amplitude relative to PSL) and moves most rapidly (a small phase difference relative to PSL) when the D_1 wave itself is small (~d 73 and 87). See Figure 7.5a for the time variation of

D_1 amplitude. When the D_1 wave is large (~d 80 and 92), the MBS impedance amplitude and phase difference have intermediate values. These patterns suggest that D_1 responds to frictional damping from D_2 as well as from its own propagation. Complex patterns are, therefore, expected for D_1. Despite some noise, Figure 7.7 suggests that the D_2 wave at MBN and MBS is largest (relative to PSL) and moves most quickly on neap tides when the D_2 wave is weak (~d 78 and 93). See Figure 7.5a for the time variation of D_2 amplitude. The relative D_2 amplitude is smaller and the wave somewhat delayed in reaching station MBS on spring tides when the D_2 wave is large (~d 70, 87, and >97) – these results are expected from the non-linear interaction of the tidal wave with bed friction.

The tests of major tidal species against MBPP intake flow also yield a clear result, at least for the available range of MBPP flows. Despite some scatter in the results for ratios of MBPP intake flow to river flow of <0.04, there is no physically meaningful dependence in Figures 7.8 and 7.9 of the impedance amplitude or phase difference for the larger tidal species on the square root of MBPP intake flow.[5] The scatter at low MBPP intake flow levels reflects the large number of data points for low plant operation levels. If more data were available for higher MBPP intake levels, a similar scatter would also likely be seen. The MBN vs. PSL and MBS vs. MBN were also calculated, but did not reveal any additional information. Thus, there is a negative outcome for the major tidal species with regard to H2a.

The potential effects of river flow on the impedance amplitudes and phase differences for D_1 and D_2 are shown in Figures 7.10 and 7.11. Just as with MBPP intake flow, amplitudes and phase differences are plotted against the square root of the river flow. The dynamic range of river flow during the March-April 1998 period was too limited (~0.2 to 1% of the tidal prism) to support any conclusions regarding the influence of river flow on the major tidal species during this time period (under H2b). Just as with the MBPP intake flow results, there is considerable scatter in the results at a river flow to tidal prism ratio of ~0.004. This scatter reflects the large number of data points at that flow level.

[5] Impedance amplitudes and phase differences are plotted against the square root of MBPP intake or river flow because, if there is a response of the tides to mean flow, tidal theory suggests that impacts will vary with the square root of the mean flow.

7.3.2. *The Overtides, D_4 and D_6*

Results reported here for the overtides focus on D_4 and D_6 for several reasons:

- Tidal theory (above) suggests that D_4 and D_6 should respond differently to the presence of a mean flow. To the extent that these overtides arise from bed friction, D_4 should increase (relative to local D_2) with increasing mean flow, while D_6 should decrease. D_4 may also initially increase relative to D_2 at the coast, as flow increases. For very strong mean flows, D_4 at an estuarine station must decrease relative to amplitude D_2 at the coast, but it will not decrease as rapidly as D_2 at the estuarine station. If any response to a mean flow were to be detected, a consistent response from these two overtides would help to validate the result.
- Variations in D_4 and D_6 are relatively easy to detect with wavelet filters, because these overtides are typically larger than adjacent tidal species.
- D_3 is not used for two reasons. First, D_3 is close in frequency to the much more energetic D_2 species, which may contaminate the D_3 result. Second, it is harder to predict or interpret the behavior of D_3. Like D_4, D_3 can arise from a quadratic interaction of D_1 with D_2 (making it proportional to b in eq. 1); in this case it should increase (relative to the major tidal species) with increasing mean flow. D_3 can, however, also be created by a cubic interaction of D_1 with itself (making it proportional to c in eq. 1), in which case it should decrease with increasing mean flow. Thus, no clear prediction can be made with regard to D_3 behavior.
- D_8 is small and arises only from very non-linear processes, resulting in a noisy signal, so D_8 is also not considered here.

The time variation of D_4 and D_6 overtide amplitudes and phases (relative values in Figures 7.12 and 7.13 and absolute amplitudes in Figure 7.5a) show complex variations, perhaps because both overtides are (in absolute terms) small in the bay, though much larger than at a coastal station like PSL. In particular, the D_4 phases at MBN are likely not significant, because of the small amplitude of D_4 at MBN. In contrast, D_6 phases at MBN do appear meaningful, with the largest phase difference (greatest time difference between processes in the bay and at the coastal station) occurring on neap tide. There is also a weak but clear pattern for the D_4 phases at MBS, where the shortest delays (smallest phase) are seen on neap tides, when friction is minimized. This behavior does not hold for the D_6 phase at MBS, where neap tides have both the largest and smallest phase delays. An interesting feature of the overtide amplitude patterns, especially for D_6, is that absolute amplitude does increase on spring tides (as predicted by theory; see Figure 7.5a), but D_6 amplitude relative to the cube of D_2 does not. Thus, the largest amplitudes for both D_4 and D_6 occur at about d 78-82, at the end of the neap tide. This means that overtide generation is not as strong as expected from the simplest possible physical interpretation of overtides in the bay, given in Sections 4.2 and 4.3. A longer data record will be required to provide a definitive physical interpretation of the overtides in the bay.

The situation with regard to the behavior of the overtides relative to the MBPP intake flow is simpler. Though there is some scatter in the results for low MBPP intake flow levels, there is no physically meaningful dependence in Figures 7.14 and 7.15 of the impedance amplitude or phase difference for the overtide species D_4 and D_6 on MBPP intake flow, over the available range of MBPP flows. The M_6 signal at MBS is particularly clear, because the scatter in M_6 phase is small at MBS. The MBN vs. PSL and MBS vs. MBN were also calculated, but were too noisy to interpret, likely because overtide amplitudes at MBN are small and quite noisy. Thus, there is a negative outcome with regard to H2a for the overtide species also.

The potential effects of river flow on the impedance amplitudes and phases for D_4 and D_6 are shown in Figures 7.16 and 7.17. The dynamic range of river flow during the March-April 1998 period was too limited (~0.2 to 1% of the tidal prism) to support any conclusions regarding the influence of river flow on the non-linear overtide species during this time period (H2b).

7.3.3. *Summary for Hypothesis H2 – Surface Elevation Analyses*

Tests of the linear tidal species (D_1 and D_2) at stations MBS and MBN failed to show any perturbations of tidal elevation properties that could be correlated with MBPP intake flow or river inflow. Tests of non-linearly generated overtides focused on D_4 and D_6, because these are the two largest overtides in the bay. Also, specific predictions are available as to their reactions to the presence of a mean flow – if a mean flow is above a threshold level, it should cause D_4 to increase and D_6 to decrease relative to local D_2. Although there is some random variability in the analysis results, no perturbations in overtide properties were found that could be related to the presence of mean flows (either MBPP intake flow or river inflow). Thus, H2 was falsified with respect to both MBPP intake flow and river flow for this data set. Because the MBPP is located close to the estuary entrance, it is not expected that MBPP intake flow will have any effect on the tides in the interior of the bay, even at an intake flow level corresponding to full plant operation. Higher river flow levels would, however, likely produce substantial effects on D_1, D_2, and the overtides. The following section demonstrates the correctness of these conclusions.

7.4. *Hypothesis H2 – Tidal Currents*

It is particularly desirable to use the 1995-97 PG&E Fairbank Point current meter record to test hypothesis H2, because it is the longest oceanographic data record available for Morro Bay. During the period that the current meter was in the water, the MBPP intake flow varied over almost its entire range, from ca. 50 to 612 MGD out of a maximum possible range of 0 to 668 MGD. The corresponding range of the ratio of MBPP intake flow to tidal prism was 0.46 to 8.8%. The range of Chorro Creek flow was from 1.1 to 457 $ft^3\ s^{-1}$ (0.0012 to 4.57 % of the tidal prism). Total freshwater inflow to the bay was likely 0.2 to ~80 $ft^3\ s^{-1}$ larger than this, because of the input from Los Osos Creek. Still, these river flow levels are modest, corresponding to about one-third of the two-year return flow level. The river flow levels are also less than the MBPP intake flow, which can reach ca. 1,000 $ft^3\ s^{-1}$ (which corresponds to 668 MGD). Nonetheless, it will be seen that the river flow has a larger effect on tidal processes in the bay than the MBPP intake flow, because the mean flow due to the river flow occurs throughout a large part of the bay, including relatively shallow areas where tidal currents are weak. River flow appreciably increases friction in these areas. In contrast, the mean flow related MBPP intake flow occurs only in a deep part of the bay between the MBPP and the ocean entrance. Tidal currents are relatively strong in this part of the bay, and the MBPP intake flow has little effect on friction.

A long time series is advantageous for understanding the interaction of the tides with a mean flow (Hypothesis H2), but provides so much information that a qualitative discussion of the many physical processes that occurred in the 1995-97 period would be quite lengthy. As such it is beyond the scope of this work. The discussion that follows considers, therefore, only the relationship of the tidal currents with the MBPP intake flow and the river flow.

7.4.1. *The Major Tidal Species, D_1 and D_2*

The interaction of the major tidal constituents (D_1 and D_2) with the mean flow is shown in Figures 7.18 –7.19 (tides vs. MBPP intake flow) and 7.20-7.21 (tides vs. river flow). The plots of D_1 and D_2 impedance vs. MBPP intake flow give a superficial appearance that the strength of the tides actually increases with increasing MBPP intake flow. This interpretation is contrary to physical reasoning – if a mean flow is significant in the dynamics of an estuary, increased mean flow increases friction and decreases tidal currents. Moreover, a closer examination of the data does not bear out this initial impression. Most of the ~1500 points represent a limited range of low-moderate MBPP intake flow levels, and the scatter of the data at these intake flow levels is quite large. Thus, a regression analysis cannot yield a slope significantly different from zero at any reasonable confidence level. The implication is simple – there are other processes that create this scatter and are more important than MBPP intake flow in governing tidal processes. As discussed below, river flow is the primary factor involved. This negative result for H2a with regard to D_1 and D_2 is important, because the range of MBPP intake flow levels for this current meter data set covers almost the entire range of possible intake flows. Moreover, the current meter was located near Fairbank Point, the boundary between the outer part of the bay and the delta and back bay. If no effects of the MBPP can be observed in a current record collected at Fairbank Point, then it is very unlikely that any effects would be observed further landward.

The relationship between river flow and the major tidal species in Morro Bay is different – river flow has a significant effect on tidal processes (Figures 7.20 and 7.21). For the higher river flows, D_1 and especially D_2 impedance amplitudes are outside of the range established by the bulk of the data that correspond to low river flow. The phase differences are more ambiguous, and no clear inference could be drawn from the phase differences alone. Still, the increase in phase difference with increased river flow suggested by Figure 7.21 is consistent with enhanced friction; because friction slows wave propagation and increases phase differences relative to an external coastal station not affected by river flow.

The evident decrease in D_2 with increasing river flow is ecologically significant – D_2 is the largest tidal species and in large part determines tidal range. The fact that tidal range and tidal exchange decrease during high flow periods is, moreover, favorable for sediment retention in back bay. That is, high river flow increases salinity differences between the bay and the ocean, increasing the tendency toward development of a two-layer estuarine exchange, with inflow near the bed. This inflow tends to trap sediment in back bay and the area of the deltas, where much sediment accretion has occurred over the last century. Weak tidal currents enhance two-layer estuarine circulation, by reducing the turbulent mixing that decreases estuarine salinity gradients. The fact that high river inflow reduces tidal currents at the same time that it increases salinity gradients means that estuarine circulation will be greatly enhanced during and after flood events, when sediment supply is high.

7.4.2. *The Overtides, D_4 and D_6*

Results for the overtides support the picture developed above – river inflow has an important effect on the tidal dynamics of Morro Bay, while the MBPP intake flow is unimportant. Figures 7.22 and 7.23 test the relationship of D_4 and D_6 properties to MBPP intake flow. In addition to the impedance amplitude and phase difference relative to LA tides, local D_4 and D_6 impedance amplitudes have been provided.[6] These are the ratio of Fairbank D_4 (or D_6) amplitude to Fairbank (not LA) D_2^2 (to D_2^3 for D_6). There is little or no variation in D_4 and D_6 impedance amplitudes and phase differences with MBPP intake flow, except that there are a few very high values of impedance amplitude (low values of phase difference) for low-moderate values of MBPP intake flow. These are most evident in the middle plot (of local impedance amplitude) in both Figures 7.22 and 7.23. These exceptionally high values correspond, as discussed in the next paragraph, to periods of high river inflow. The results for tidal current overtides confirm, therefore, the results for the tidal elevations and for tidal current D_1 and D_2 – there is simply no relationship between tidal processes in the interior of the bay and MBPP intake flow. Thus, there is a clear negative result for Hypothesis H2a.

Figures 7.24 and 7.25 show the effects of river inflow on overtide properties. As with Figures 7.22 and 7.23, a local impedance amplitude is shown along with the impedance amplitude and phase difference relative to LA tides. Fairbank Point D_4 current amplitude shows a strong increase (and phase difference a definite decrease) as river flow increases. The local impedance amplitude and phase difference (relative to LA) both show this effect clearly – values

[6] The local phase differences have not been included, because they did not provide any additional information.

for high river flow are outside the range established by low to moderate river flows. This is consistent both with predictions (in Section 4.3), and with the decrease in D_1 and D_2 amplitudes with river flow discussed above. That is, increased river flow causes energy to be lost from the main tidal species (D_1 and D_2); it is transferred by bed friction to overtide species such as D_3 and D_4.

The result for D_6 in Figure 7.25 is similarly consistent with predictions. The predicted behavior of D_6 was that it should decrease with increasing river flow, relative to a coastal reference station. This behavior is evident in the top panel of Figure 7.25, which shows the impedance amplitude relative to LA tides. The middle panel (local impedance amplitude) shows, however, that the decrease in D6 is less rapid than the local energy loss by D_2. The phase data are too scattered in this case to provide a clear result. Clearly, overtides D_4 and D_6 are affected by river flow in a way that is not the case for MBPP intake flow. These results for the overtide species confirm earlier results for the main tidal species, D_1 and D_2.

7.4.3. Summary for Hypothesis H2 – Analyses of Current Meter Data

A extensive S4 current meter record was available from Fairbank Point. It covers the period from November 1995 to January 1997, with a several month gap in the middle (March-July, 1996). This current meter record is especially valuable because a wide variety of MBPP intake flow levels occurred during this record, ~50 –612 MGD (compared to a total range of 0 – 668 MGD). There was also a modest Chorro Creek inflow range from 1.1 to 457 ft^3s^{-1}; i.e., up to about one-third of the two-year return flow. Even though the river inflow was only about half the maximum MBPP intake flow level during this period, river flow exerted a strong effect on tidal currents (and therefore, tidal exchange) in the interior of Morro Bay. In contrast, effects of variations of MBPP intake flow were below the “noise level”. That is, they wer enough less than variations due to natural processes, that no effect of MBPP operation on the interior of the bay could be detected. The negative result for Hypothesis H2a (the effects of the MBPP intake flow on tidal exchange) means that there are no significant effects of the MBPP intake flow on sedimentary processes of the interior of Morro Bay, including sediment transport and the historic shoaling of the bay.

Conversely, the positive result for Hypothesis H2b (the effects of river inflow on tidal exchange) has implications for shoaling of the bay. Variations in river flow definitely affect tidal range in the interior of the bay and sediment retention, not just because high river flows supply sediment, but through modulation of tidal exchange and two-layer estuarine circulation by the river flow. This is an effect of considerable ecological importance. The positive result for Hypothesis H2a also serves to validate the analysis methods used – even though river inflow levels were only half the maximum MBPP intake flow level, strong effects of river flow on tidal processes were detected. Were there any effects of the MBPP intake flow on tidal processes on the interior of the bay, they also would have been detected.

7.5. *Summary of Analyses of Tidal Heights and Currents*

A thorough analysis of tidal properties of Morro Bay has been carried out, using both surface elevation and tidal current data. Two forms of tidal analysis were used. First, harmonic analysis was used to define the average amplitude and phase of major tidal constituents, for both tides and currents. Datum levels were estimated from harmonic analysis results, and were consistent with previous estimates. Second, wavelet analyses of tidal properties provide a detailed view of the time-evolution of the frequency structure of tidal processes. The wavelet results were used for hypothesis tests.

Two hypotheses were tested in this section:

H1: The daily tidal exchange and tidal prism of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

H2: Specific tidal species and tidal constituent of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

Hypothesis H1 tests impacts on quantities of primary ecological significance, the tidal range and tidal exchange. Hypothesis H2 clarifies and validates results for H1. If a positive result is obtained for H1, then it must be explicable in terms of the individual tidal constituents considered in H2. Moreover, tests of individual tidal species are more sensitive than tests of the tidal range, which is a net result of all tidal species acting together. Hypothesis H1 was (for methodological reasons) tested using surface elevation data only, while Hypothesis H2 was tested using both surface elevation and current meter data.

Results for Hypotheses H1a and H2a (the effects of MBPP intake flow on tidal processes in the bay) were consistent. No effects of MBPP operation were detectable in the interior of the bay (using both surface elevation and current data) or near the MBPP itself (where only surface elevation data were available). This test is conclusive in that the current meter data cover almost the range of MBPP intake flow, ~50–612 MGD (compared to a total range of 0–668 MGD). This negative result for Hypotheses H1a and H2a means that adverse effects of the MBPP intake flow on shoaling processes in the interior of the bay are excluded. It is not possible for the MBPP to effect sediment transport in the shallow areas landward of Fairbank Point without acting through the tidal currents. This analysis does not, however, exclude the possibility that current data in the vicinity of the MBPP would reveal subtle effects on tidal currents near the estuary mouth.

There is a very strong contrast between the negative results for Hypotheses H1a and H2a and the positive results for Hypotheses H2b (the effects of river inflow on tidal processes in the bay). It is clear that the tidal dynamics of the bay respond strongly to river inflow – a decrease in tidal exchange was evident for river flow levels less than half of the maximum MBPP intake flow level. River inflow also strongly influences the sediment dynamics of the bay, both because high river inflow brings with it large amounts of sediment, and because river inflow changes the tidal dynamics and estuarine circulation of the bay in such a way as to favor sediment retention.

There is, furthermore, a physical reason why river inflow from Chorro and Los Osos Creeks affects Morro Bay's tidal dynamics in a way that MBPP intake flow does not. River flow enters the bay in a shallow area that has weak tidal currents and is a considerable distance from the mouth. Thus, river flow affects the entire bay from the deltas to the ocean. River inflow causes, therefore, a substantial increase in bed friction throughout much of the bay. In contrast, the MBPP intake flow exists in only between the MBPP and the mouth of the estuary. This part of the estuary is relatively deep and has much stronger tidal currents than most of the interior of the bay. The MBPP intake flow causes, therefore, only a relatively small increase in bed friction.

Finally, the analysis methods employed to test Hypotheses H1 and H2 were quite sensitive, as is evident for the positive results for Hypotheses H2b for relatively low river inflow levels of about one-third of the two-year return flow. If there were adverse effects of the MBPP intake flow on the tidal dynamics of the interior of the bay, they would have been detected.

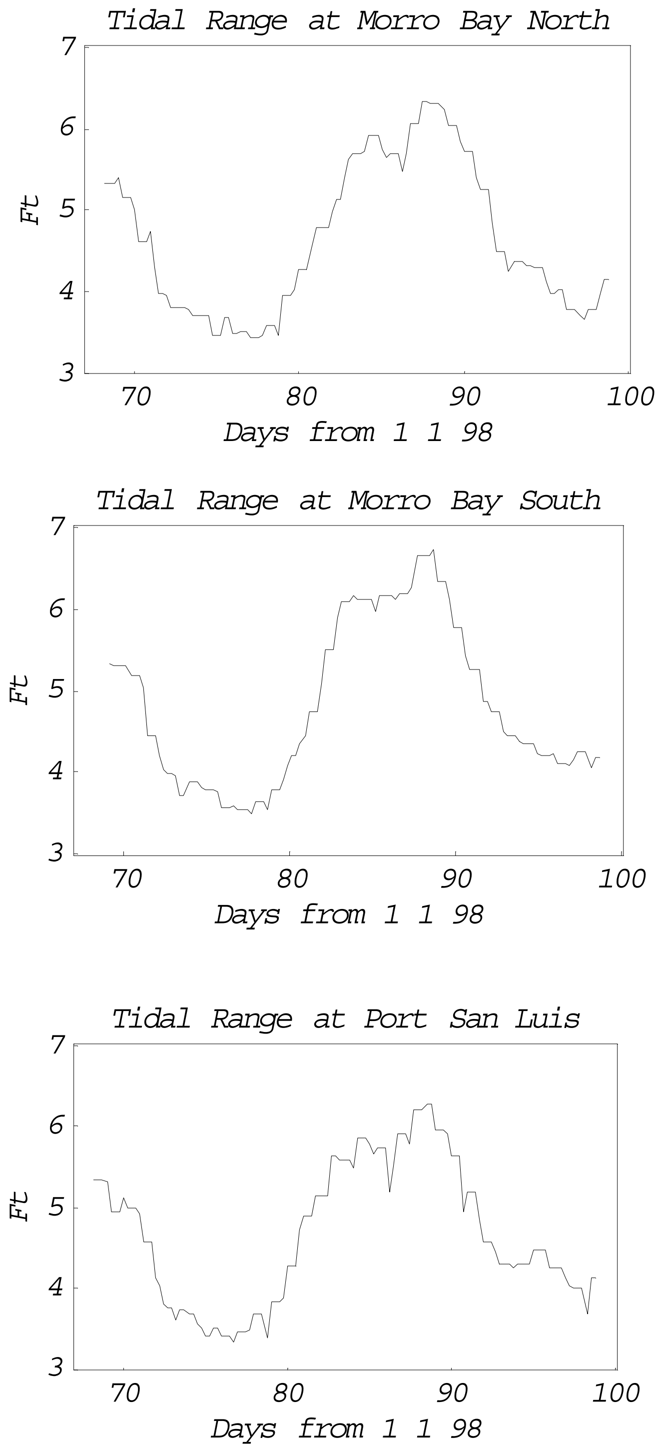


Figure 7.1*: Tidal ranges at stations MBN and MBS (above) and PSL (below).*

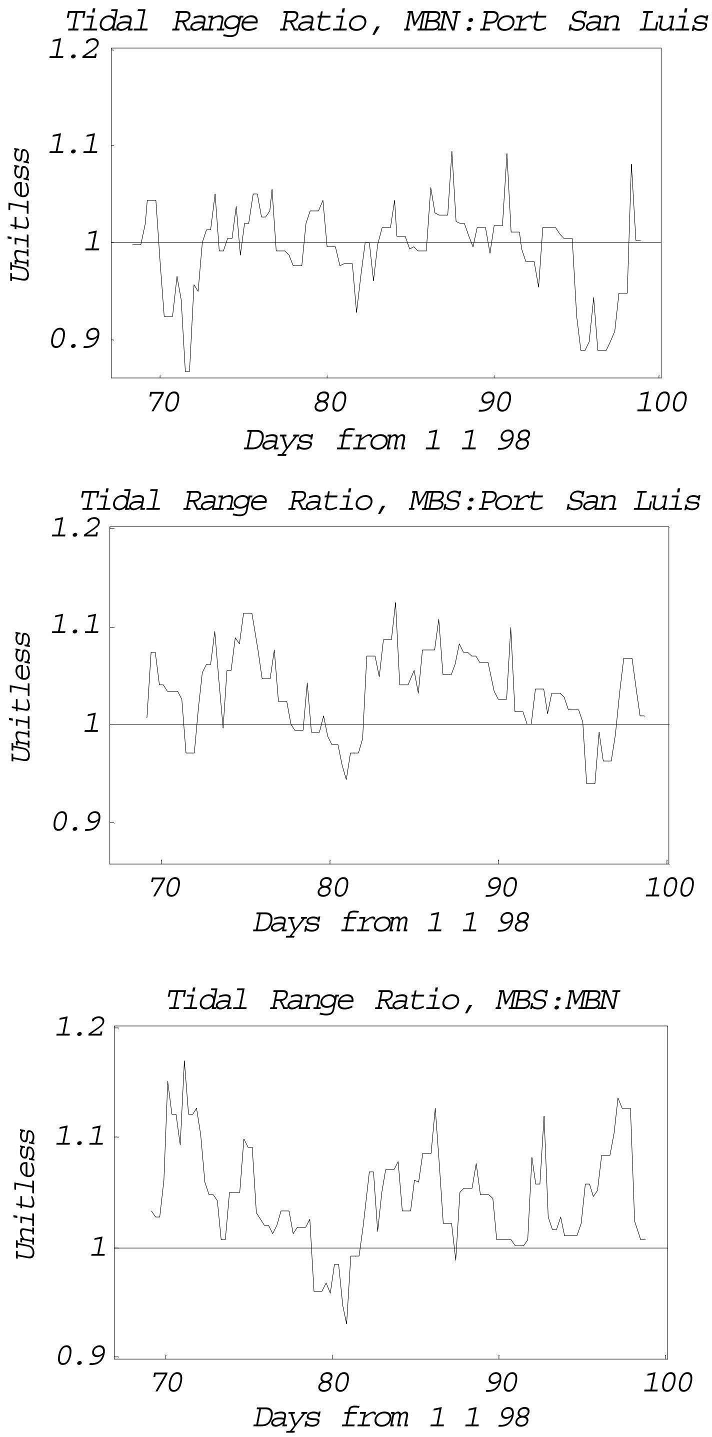


Figure 7.2*: Tidal range ratios for MBN to Port San Luis (PSL), MBS to PSL, and MBS to MBN. The tidal range is usually larger inside the bay at station MBS than near the entrance.*

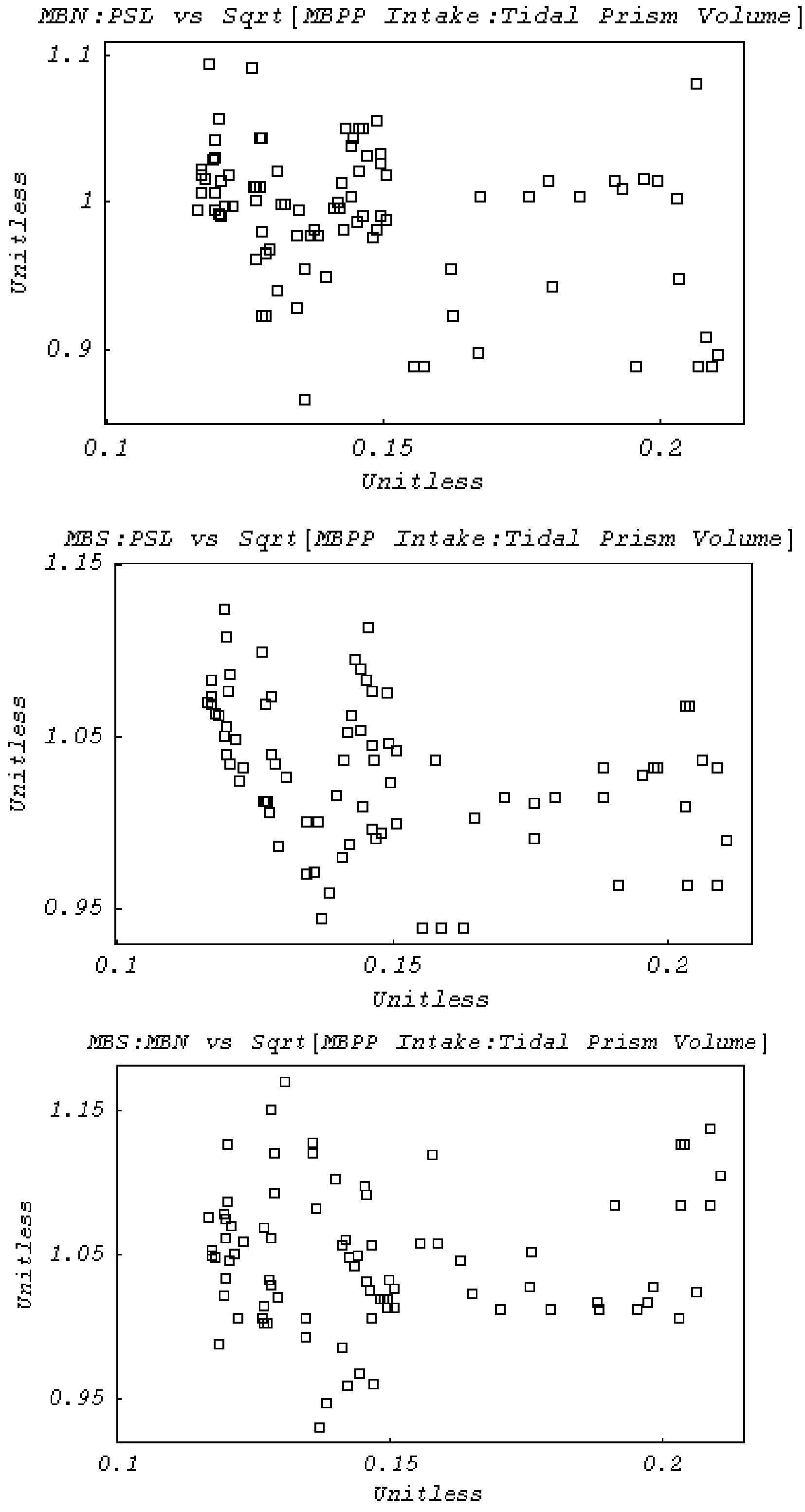


***Figure 7.3**: Scatterplots of tidal range ratios against the square root of non-dimensional MBPP intake volume, for (top to bottom) MBN to PSL, MBS to PSL, and MBN to MBS. Tidal range is plotted against the square root of flow, because any variation in tidal range should depend on the square root of mean flow.*

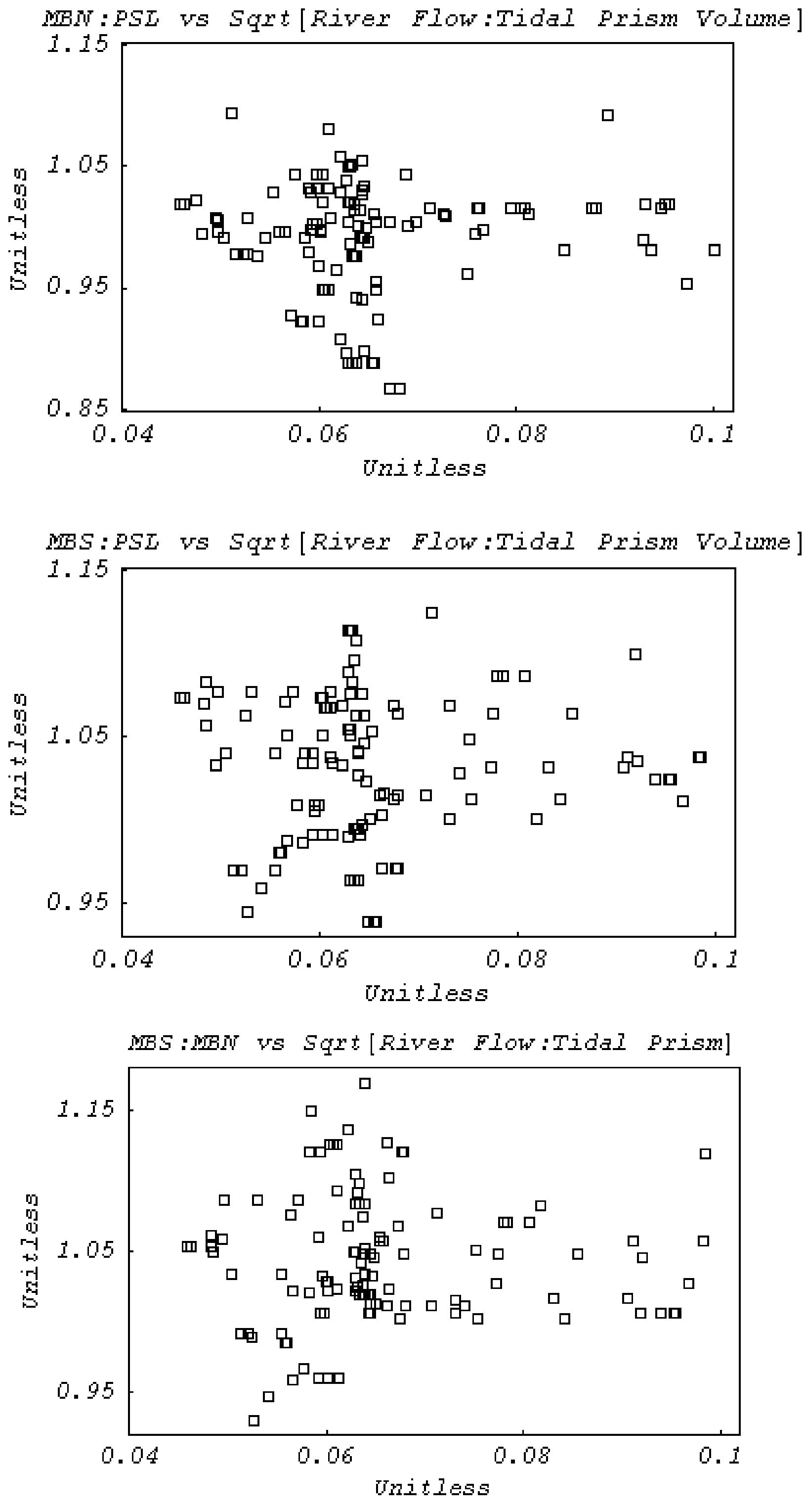


***Figure 7.4**: Scatterplots of tidal range ratios against square root of non-dimensional river in-flow for (top to bottom) MBN to PSL, MBS to PSL, and MBN:MBS.*

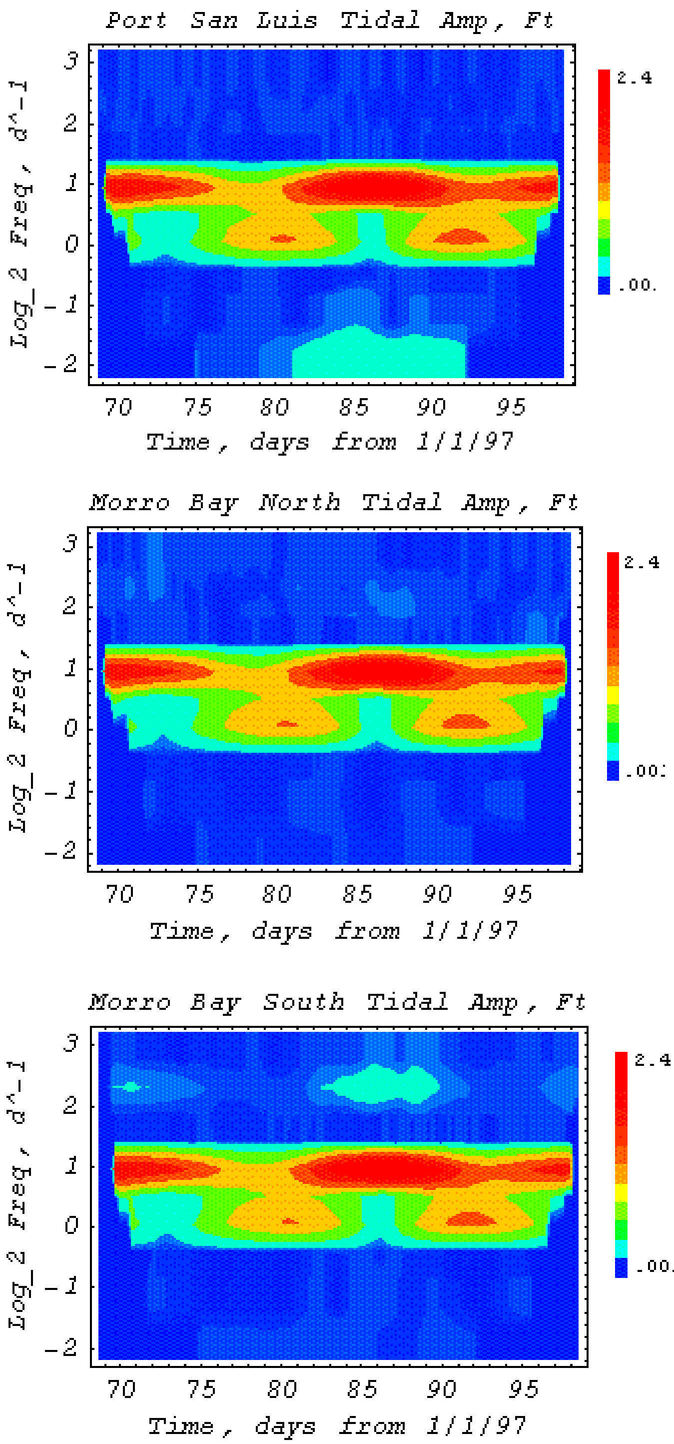
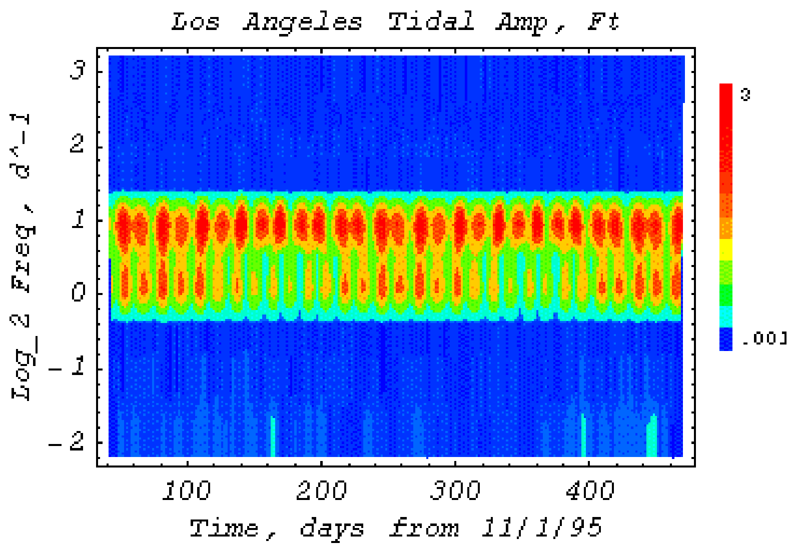


Figure 7.5a*: Amplitude scaleograms for (top to bottom) Port San Luis (PSL), and the Morro Bay stations MBN and MBS. Time in days (d) is on the horizontal (x) axis, log_2 frequency (in d^{-1}) is on the vertical (y) axis. The D_1 wave has a frequency (y-axis value) of 1 d^{-1} (with $log_2 [1] = 0$). The corresponding y-axis values for D_2, D_3, D_4 and D_6 are: 1, 1.58, 2, and 2.58, respectively.*



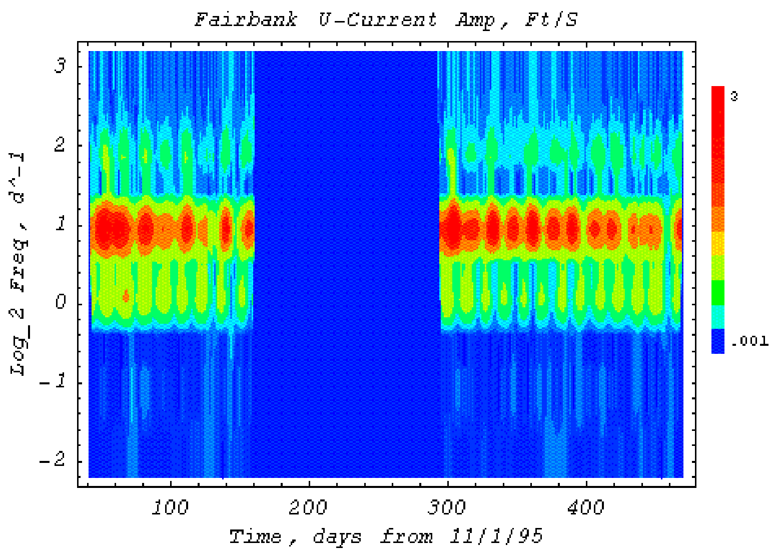


Figure 7.5b*: Amplitude scaleograms for (top) and (bottom) alongchannel current from the two PG&E deployments of an S4 current meter. Time in days from 11/1/95 (d) is on the horizontal (x) axis, log_2 frequency (in d^{-1}) is on the vertical (y) axis. The D_1 wave has a frequency (y-axis value) of 1 d^{-1} (with log_2 [1] = 0). The corresponding y-axis values for D_2, D_3, D_4 and D_6 are: 1, 1.58, 2, and 2.58, respectively. There is a gap in the PG&E current data from ca. d 170 to 290 that is indicated by the solid blue background (amplitude <0.001 ft).*

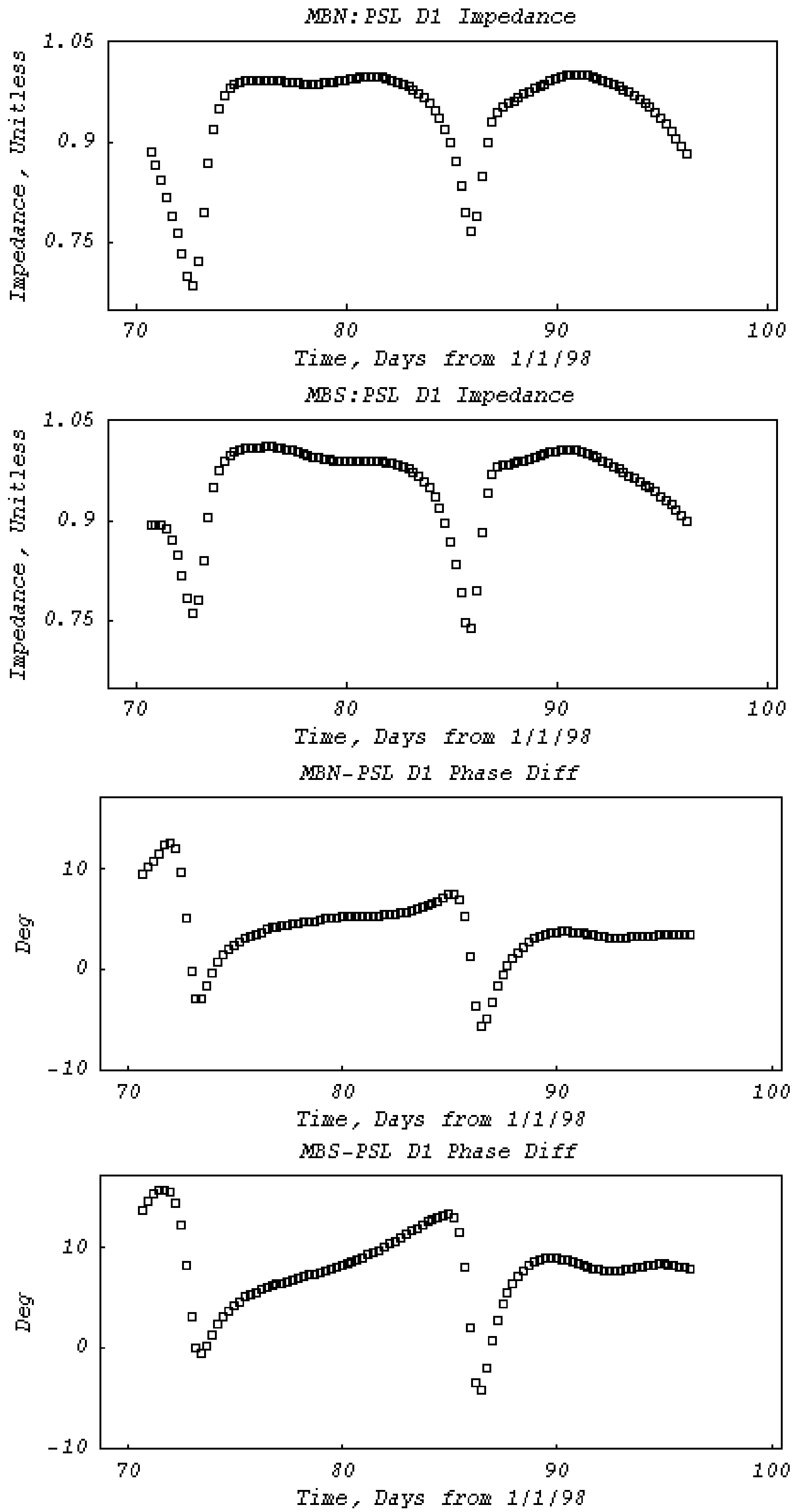


Figure 7.6*: Time series (top to bottom) of: D_1 impedance amplitude and phase difference for stations MBN and MBS. All amplitudes and phases are relative to station PSL.*

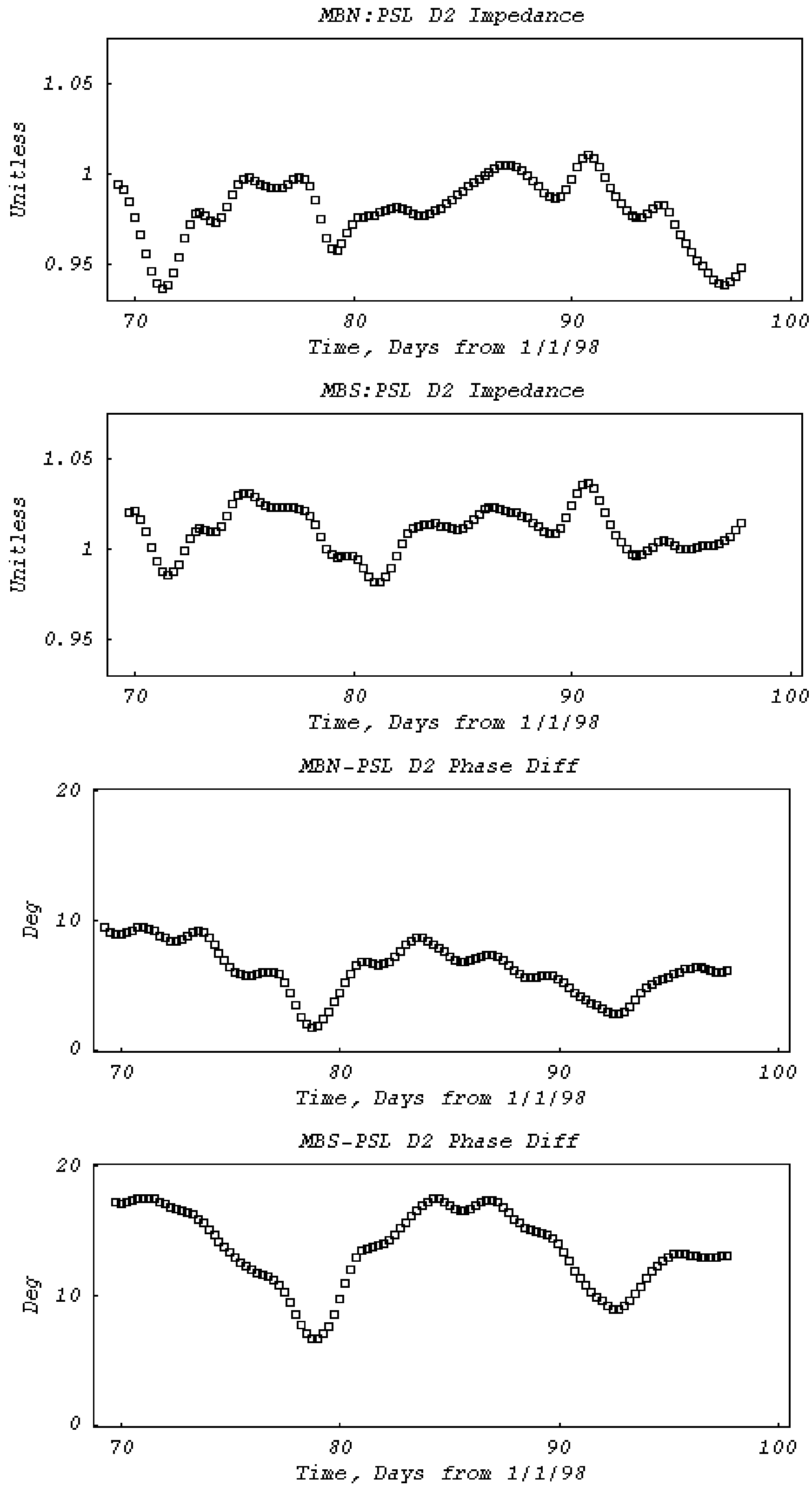
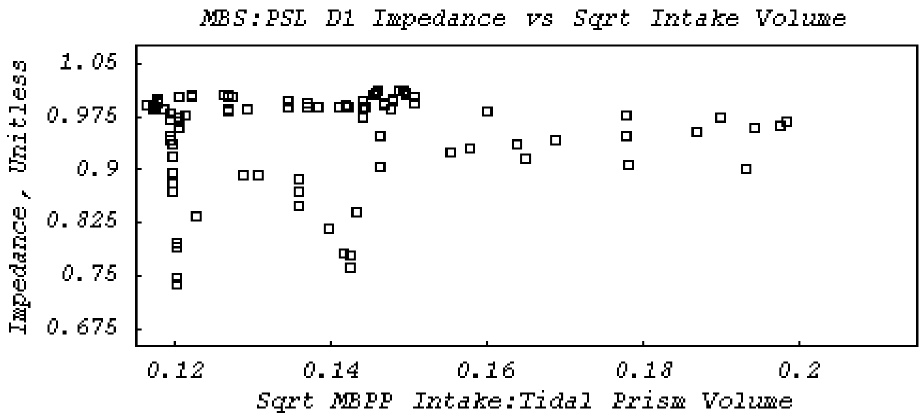


Figure 7.7*: Time series (top to bottom) of: D_2 impedance amplitude and phase difference for stations MBN and MBS. All amplitudes and phases are relative to station PSL.*



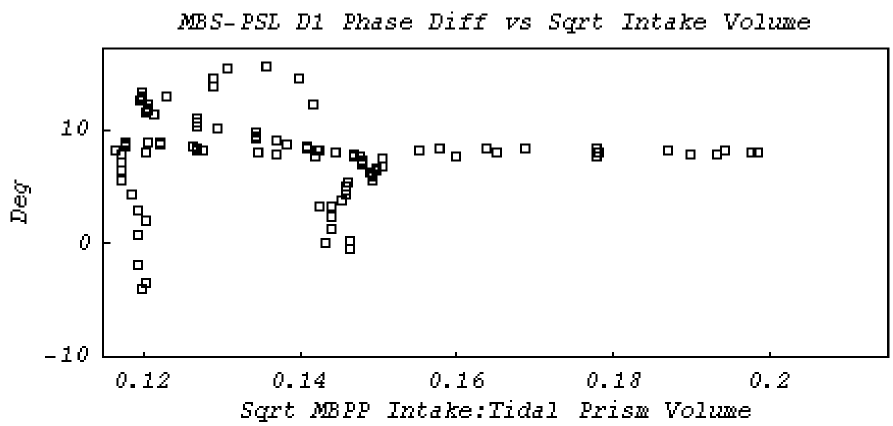


Figure 7.8*: Scatterplot of MBS D_1 impedance amplitude (top) and D_1 phase difference (bottom) vs. square root of ratio of MBPP intake flow to tidal prism. All impedance amplitudes and phases are relative to PSL.*

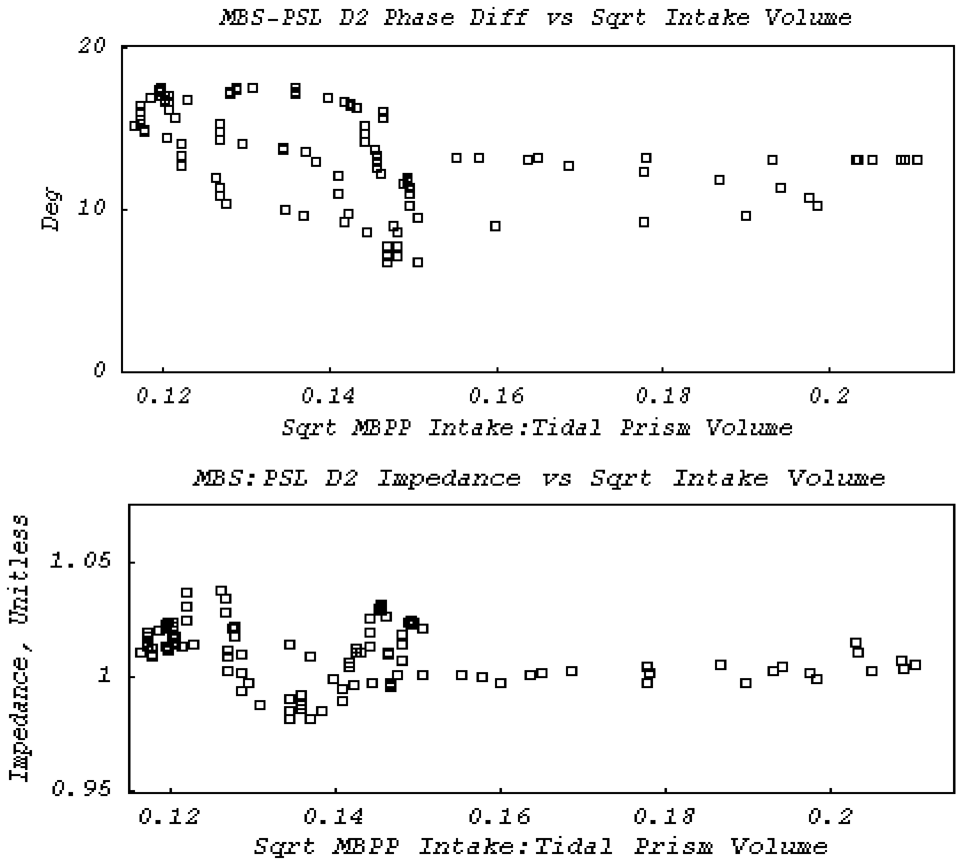


Figure 7.9: *Scatterplot of MBS D_2 impedance amplitude (top) and D_2 phase difference (bottom) vs. ratio of MBPP intake flow to tidal prism. All impedance amplitudes and phases are relative to PSL.*

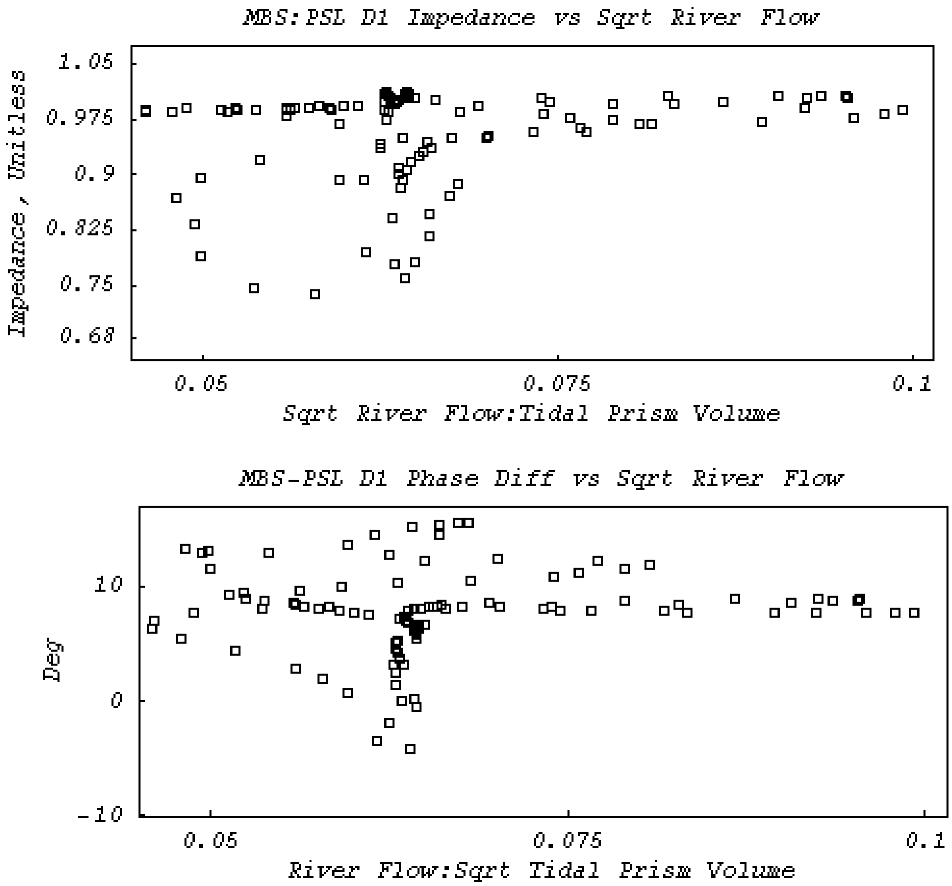
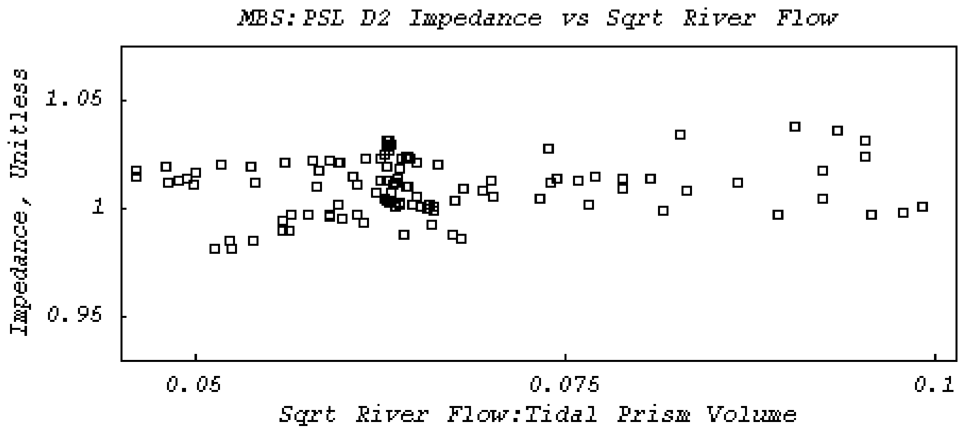


Figure 7.10: *Scatterplot of MBS D_1 impedance amplitude (top) and D_1 phase difference (bottom) vs. square root of ratio of river flow to tidal prism. All impedance amplitudes and phases are for station MBS relative to PSL.*



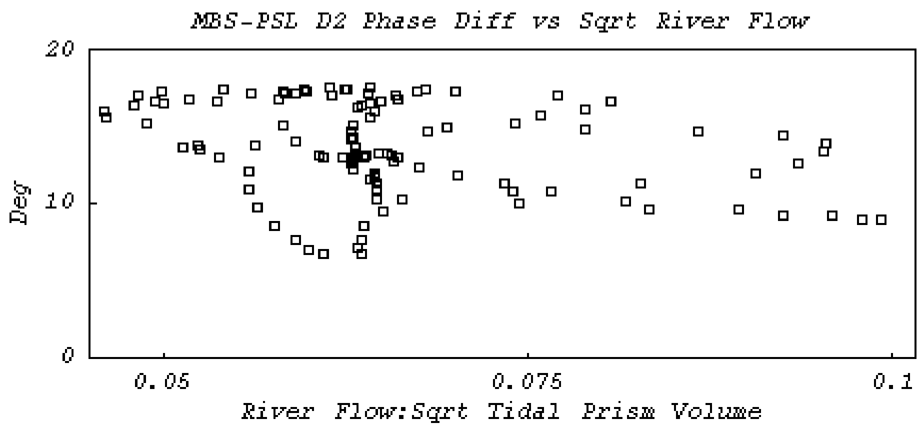


Figure 7.11: *Scatterplot of MBS D_2 impedance amplitude (top) and D_2 phase difference (bottom) vs. ratio of river flow to tidal prism. All impedance amplitudes and phases are for station MBS relative to Port San Luis.*

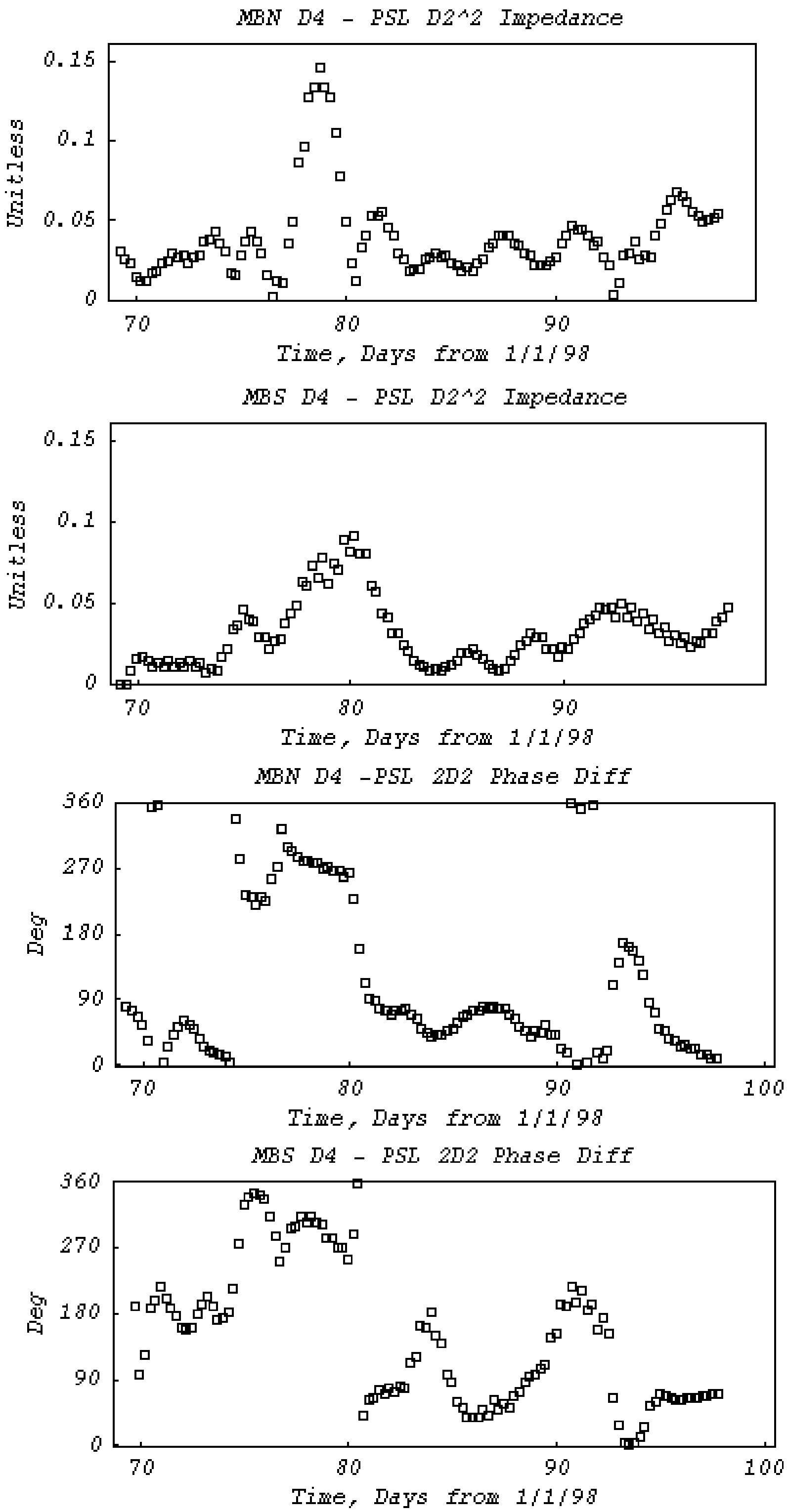


Figure 7.12: *Time series (top to bottom) of: D_4 impedance amplitude and phase difference for stations MBN and MBS. All amplitudes and phase are relative to station PSL*

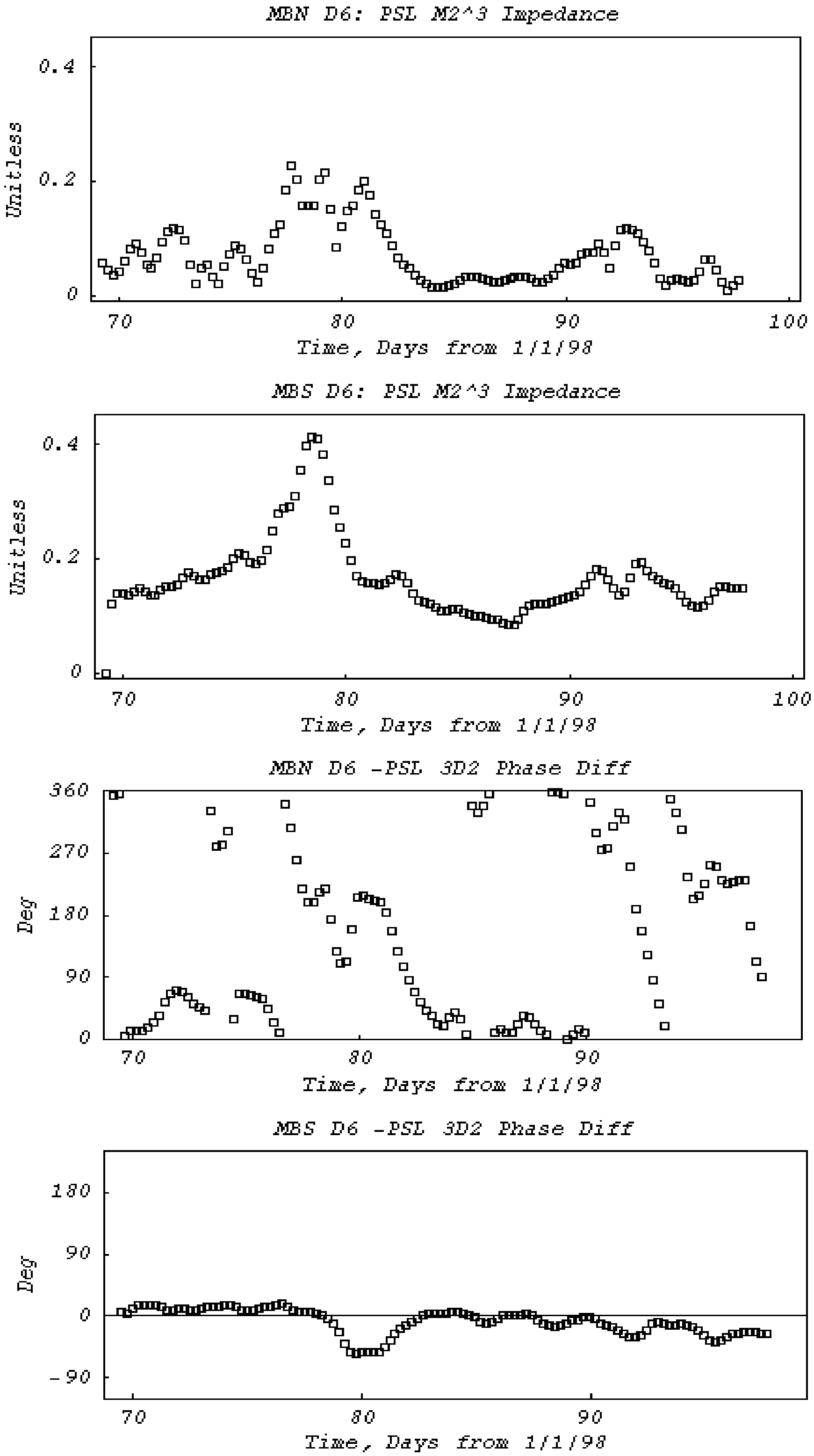


Figure 7.13: *Time series (top to bottom) of: D_4 impedance amplitude and phase difference for stations MBN and MBS. All amplitudes and phases are relative to station PSL*

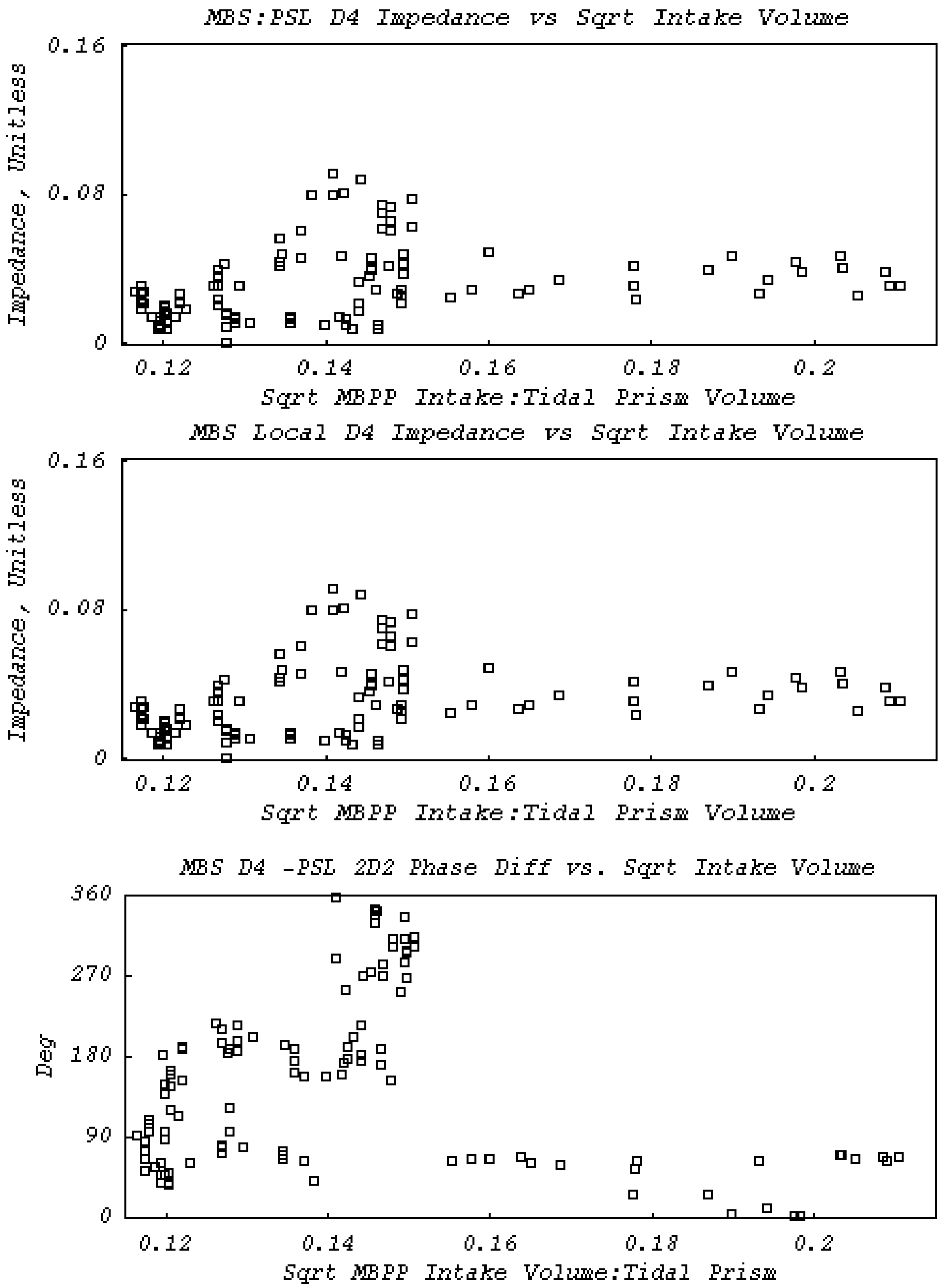


Figure 7.14: *Scatterplot of (top to bottom): MBS:PSL D_4 impedance amplitude, local D_4 impedance amplitude, and D_4 PSL phase difference (bottom) vs. square root of the ratio of MBPP intake flow to tidal prism.*

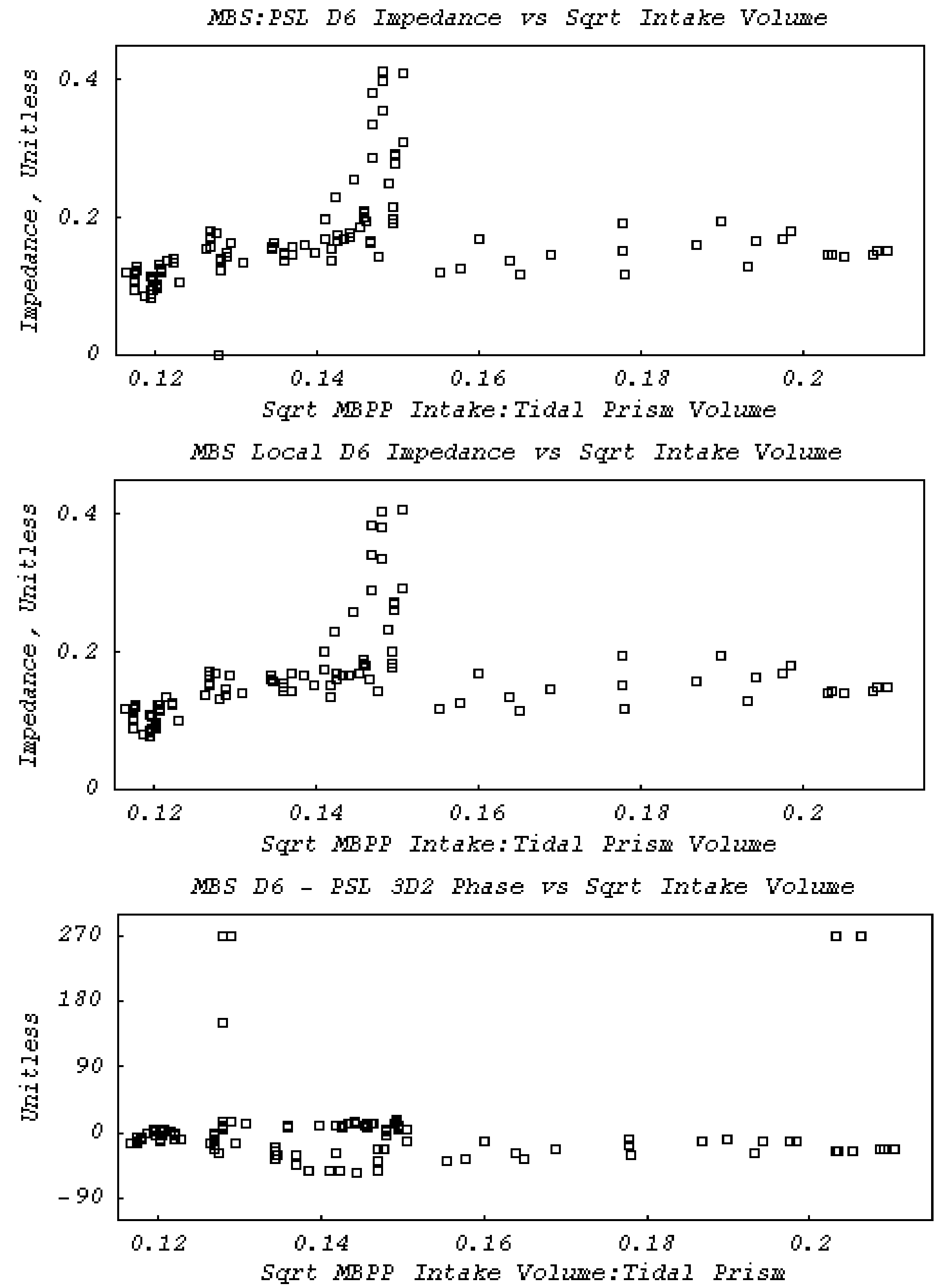


Figure 7.15: *Scatterplot of (top to bottom): MBS:PSL D_6 impedance amplitude, local D_6 impedance amplitude, and D_6 PSL phase difference (bottom) vs. square root of the ratio of MBPP intake flow to tidal prism.*

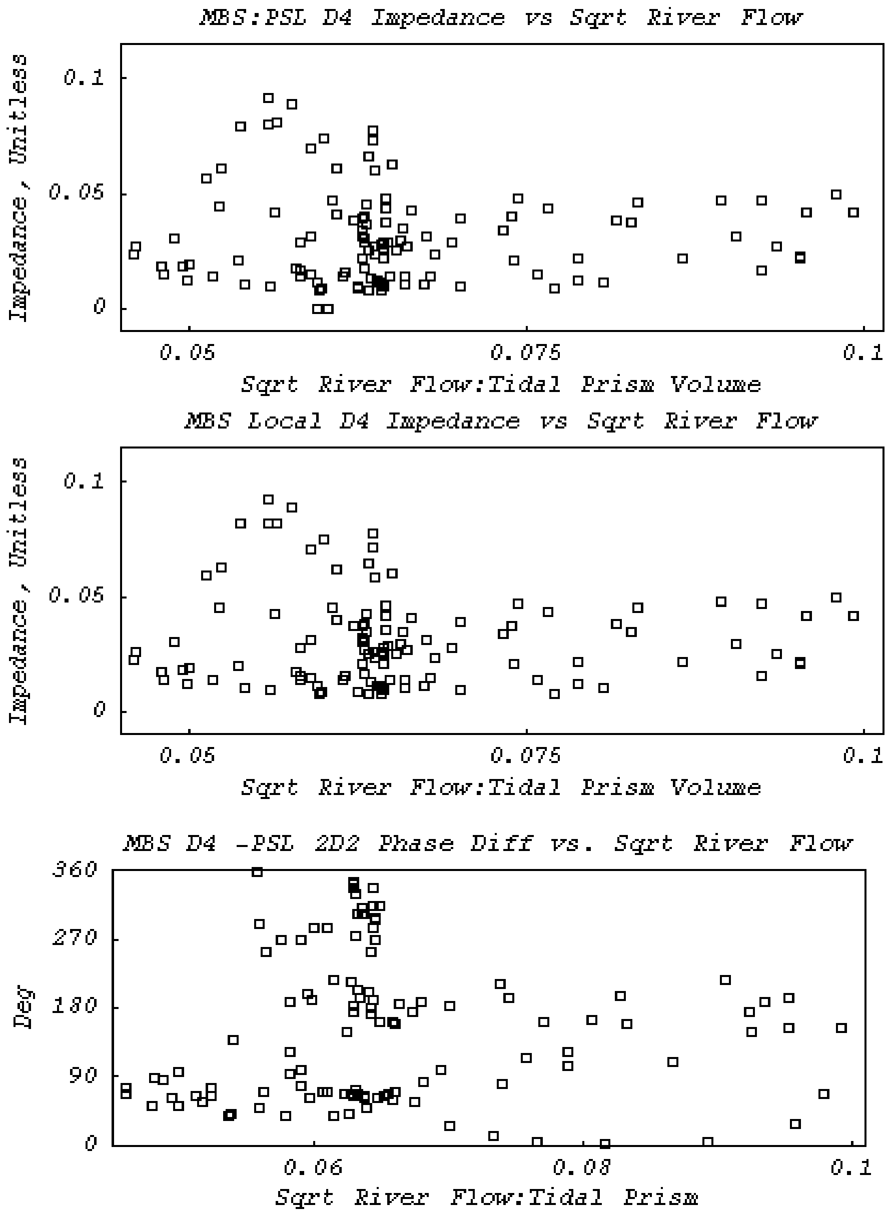


Figure 7.16s*: Scatterplot of (top to bottom): MBS:PSL D_4 impedance amplitude, local D_4 impedance amplitude, and D_4 PSL phase difference vs. square root of the ratio of river flow to tidal prism.*

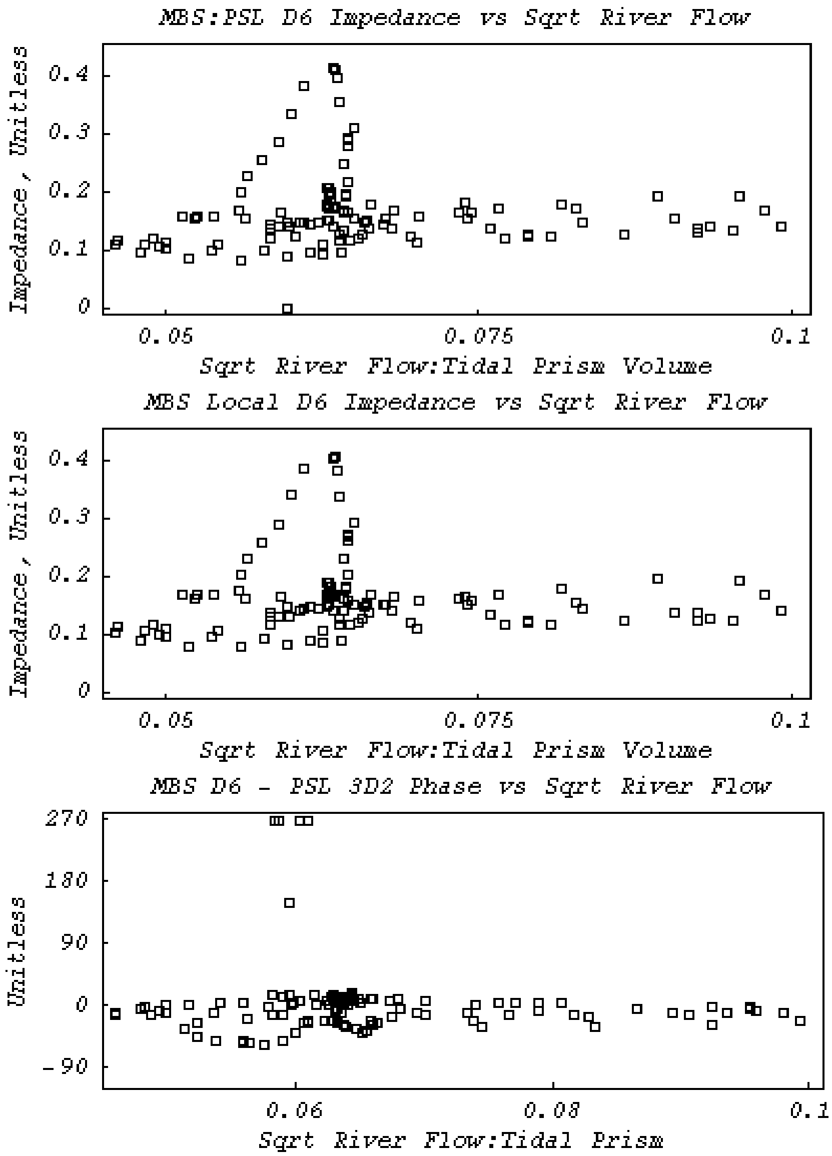


Figure 7.17: *Scatterplots of (top to bottom): MBS:PSL* D_6 *impedance amplitude, local* D_6 *impedance amplitude, and* D_6 *phase difference vs. square root of the ratio of river flow to tidal prism.*

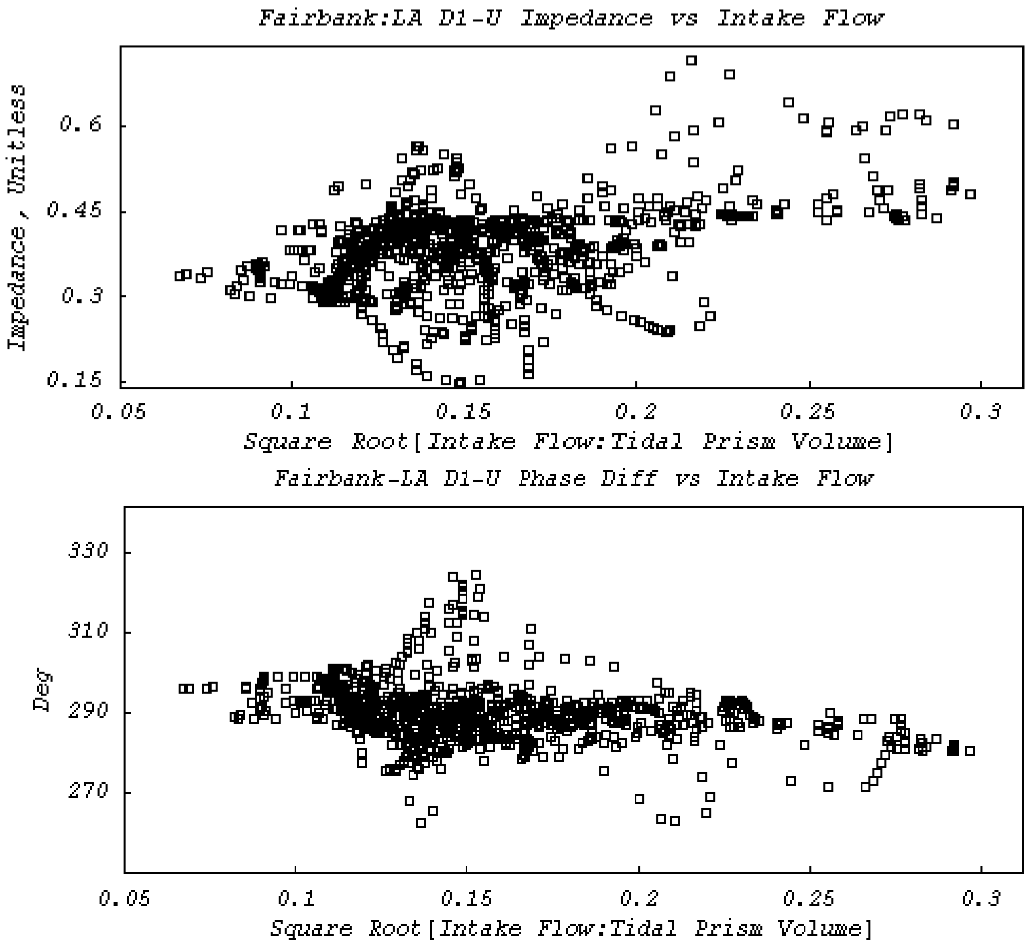


***Figure 7.18**: Scatterplot of PG&E D_1 impedance amplitude (top) and D_1 phase difference (bottom) vs. square root of ratio of MBPP intake flow to tidal prism. Impedance amplitude and phase difference are relative to Los Angeles tidal elevation.*

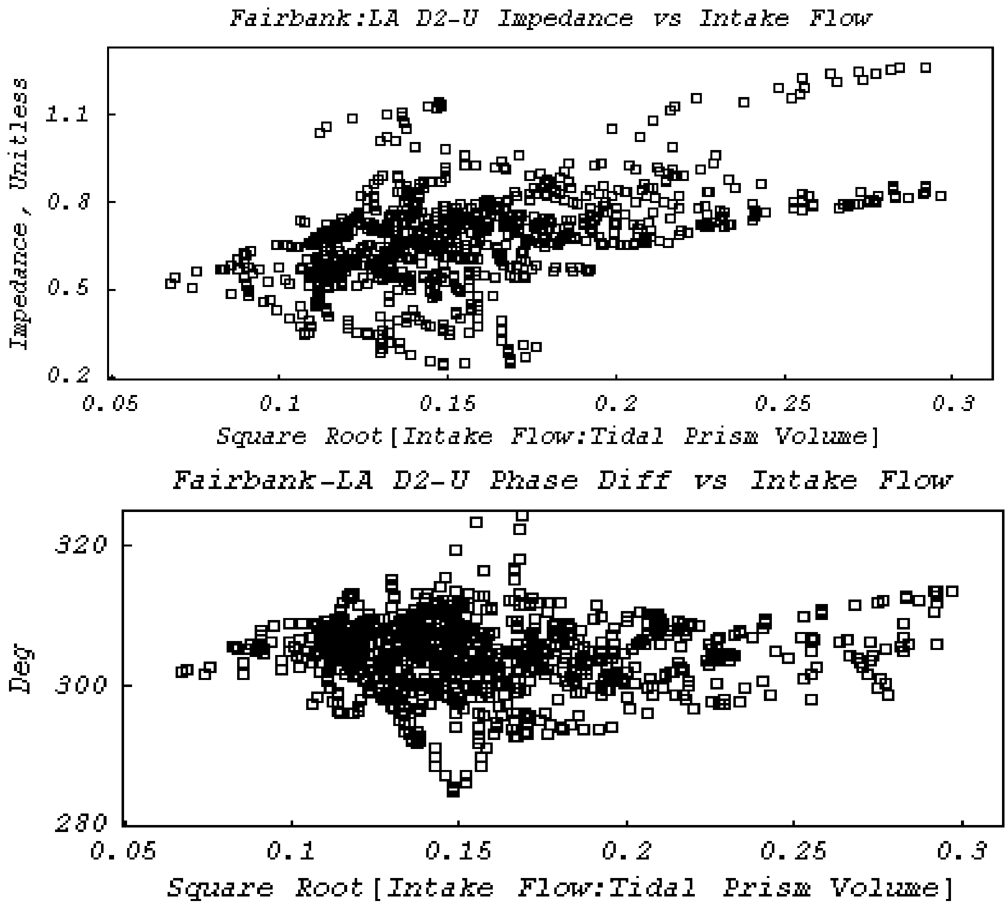
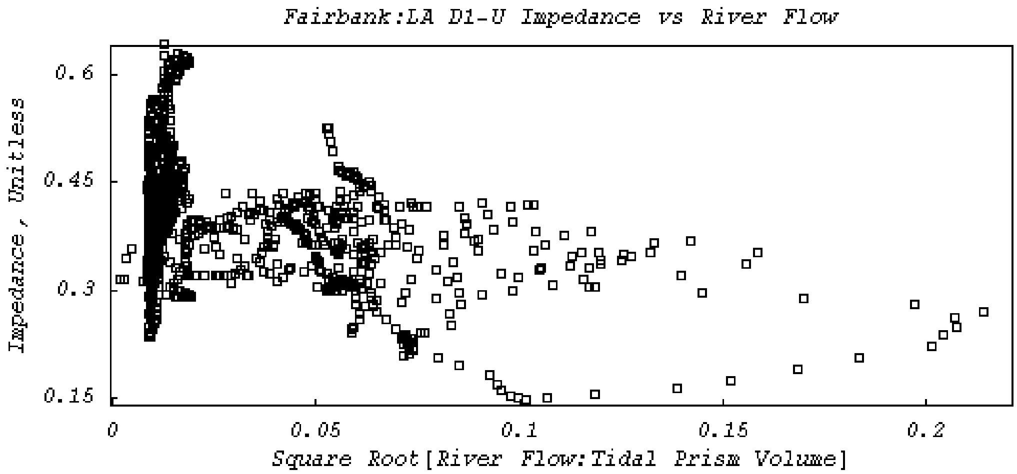


Figure 7.19: *Scatterplot of PG&E D_2 impedance amplitude (top) and D_2 phase difference (bottom) vs. square root of ratio of MBPP intake flow to tidal prism. Impedance amplitude and phase difference are relative to Los Angeles tidal elevation.*



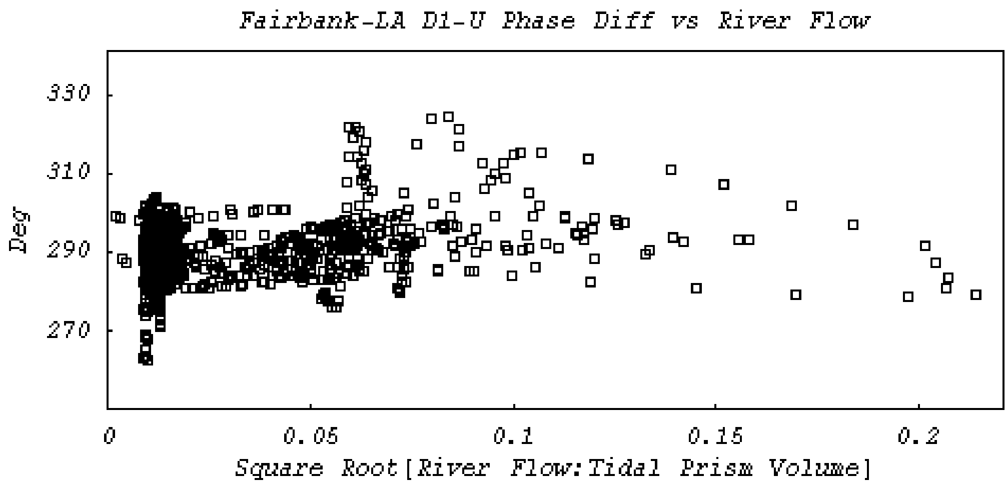


Figure 7.20: *Scatterplot of PG&E D_1 impedance amplitude (top) and D_1 phase difference (bottom) vs. square root of ratio of river flow to tidal prism. All impedance amplitudes and phases are relative to Los Angeles tidal elevation.*

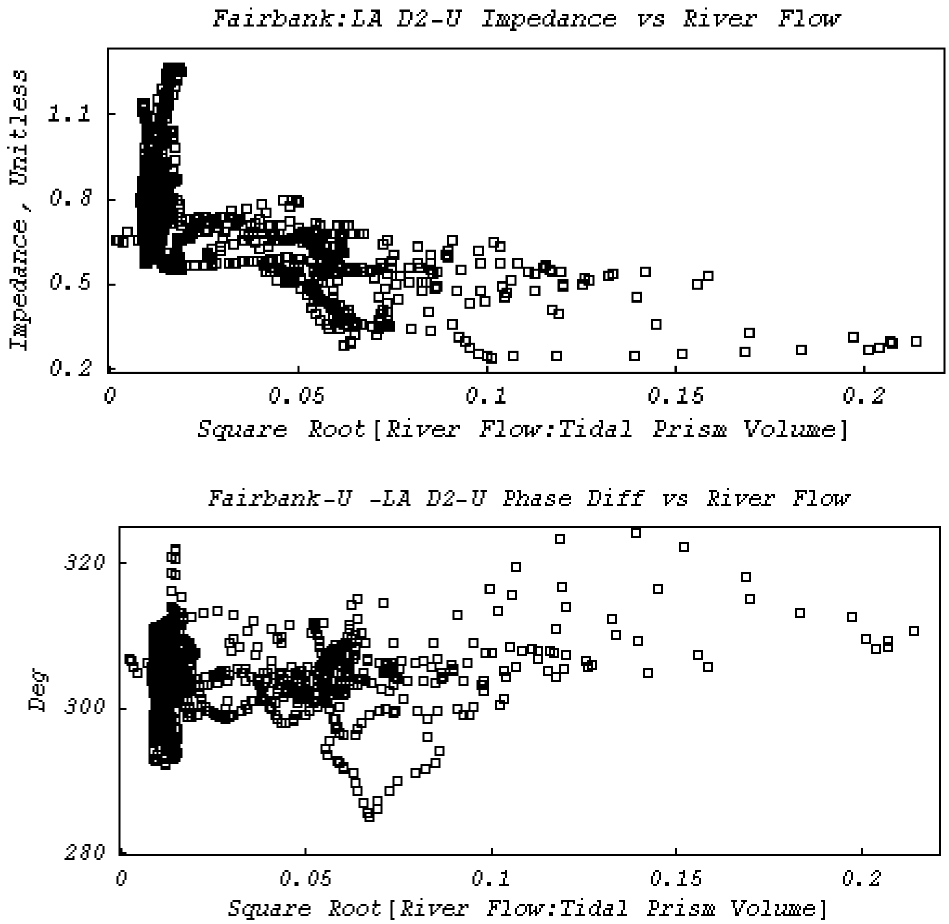


Figure 7.21: *Scatterplot of PG&E D_2 impedance amplitude (top) and D_2 phase difference (bottom) vs. square root of ratio of river flow to tidal prism. All impedance amplitudes and phases are relative to Los Angeles tidal elevation.*

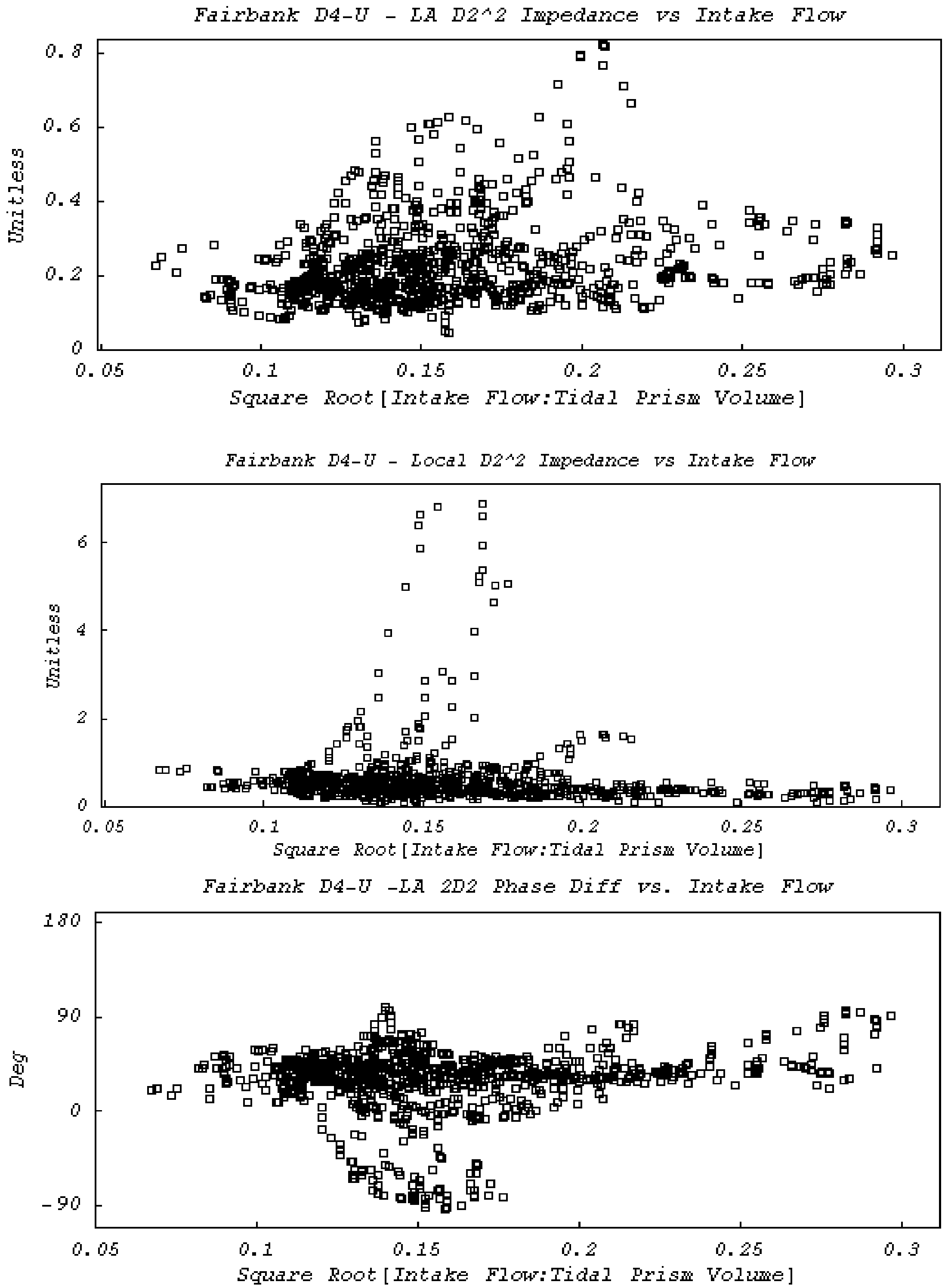


Figure 7.22: *Scatterplots of (top to bottom): PG&E:LA D_4 impedance amplitude, local D_4 impedance amplitude, and PG&E D_4 phase difference relative to LA vs. square root of the ratio of MBPP intake flow to tidal prism.*

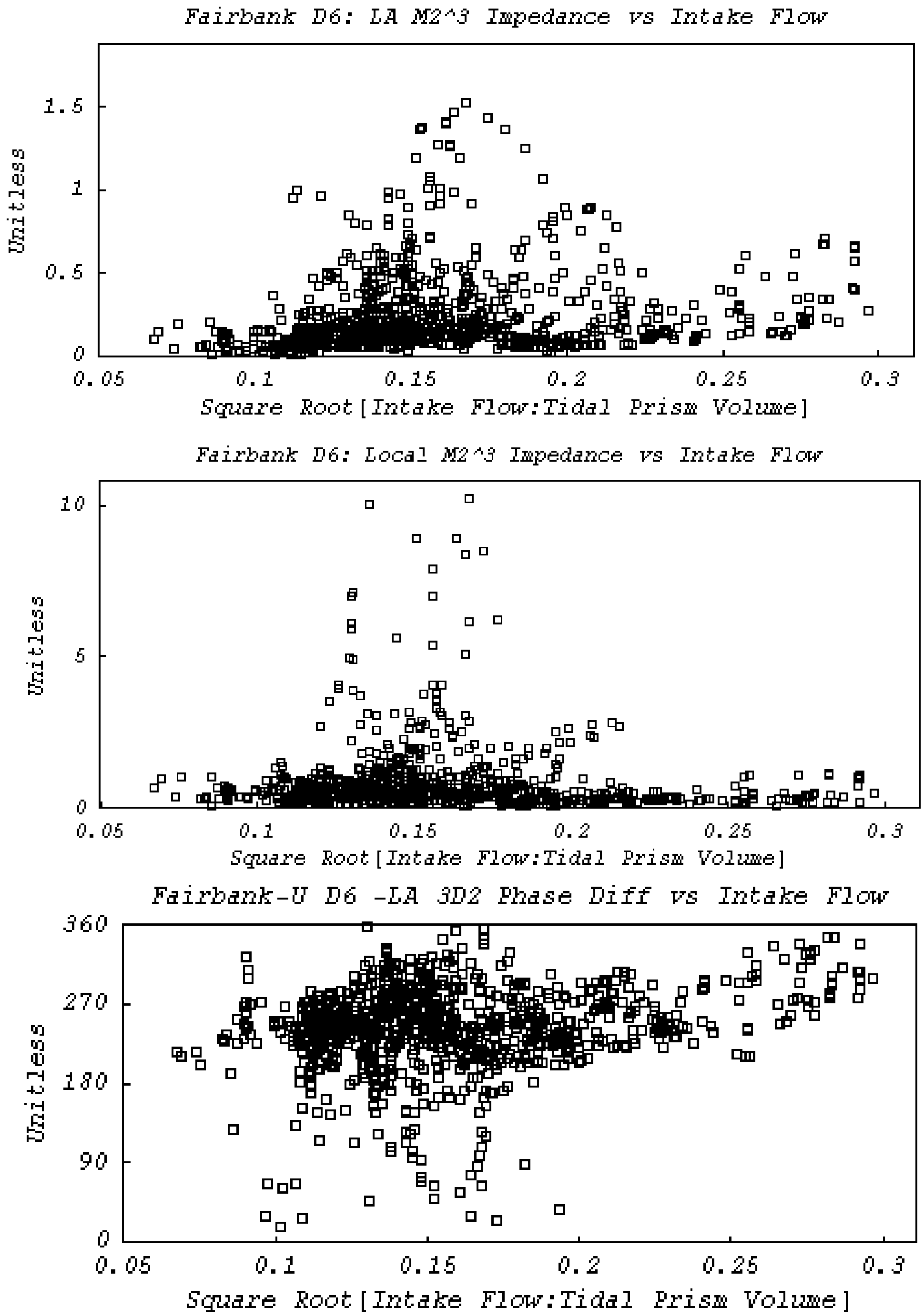


Figure 7.23: *Scatterplots of (top to bottom): PG&E:LA D_6 impedance amplitude, local D_6 impedance amplitude, and PG&E D_6 phase difference relative to LA vs. square root of the ratio of MBPP intake flow to tidal prism.*

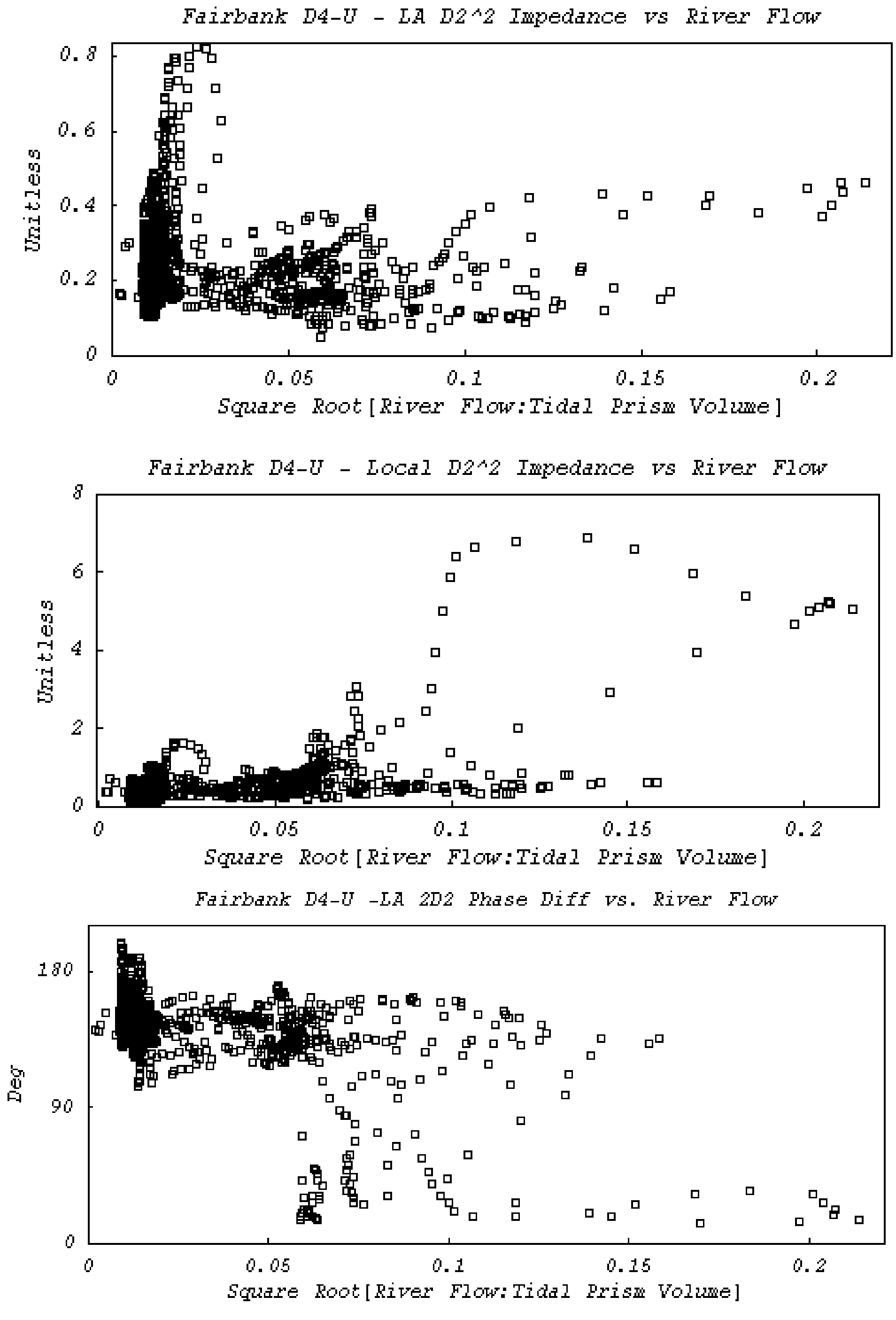


Figure 7.24: *Scatterplots of (top to bottom): PG&E:LA D_4 impedance amplitude, local D_4 impedance amplitude, and PG&E D_4 phase difference relative to LA vs. square root of the ratio of river flow to tidal prism.*

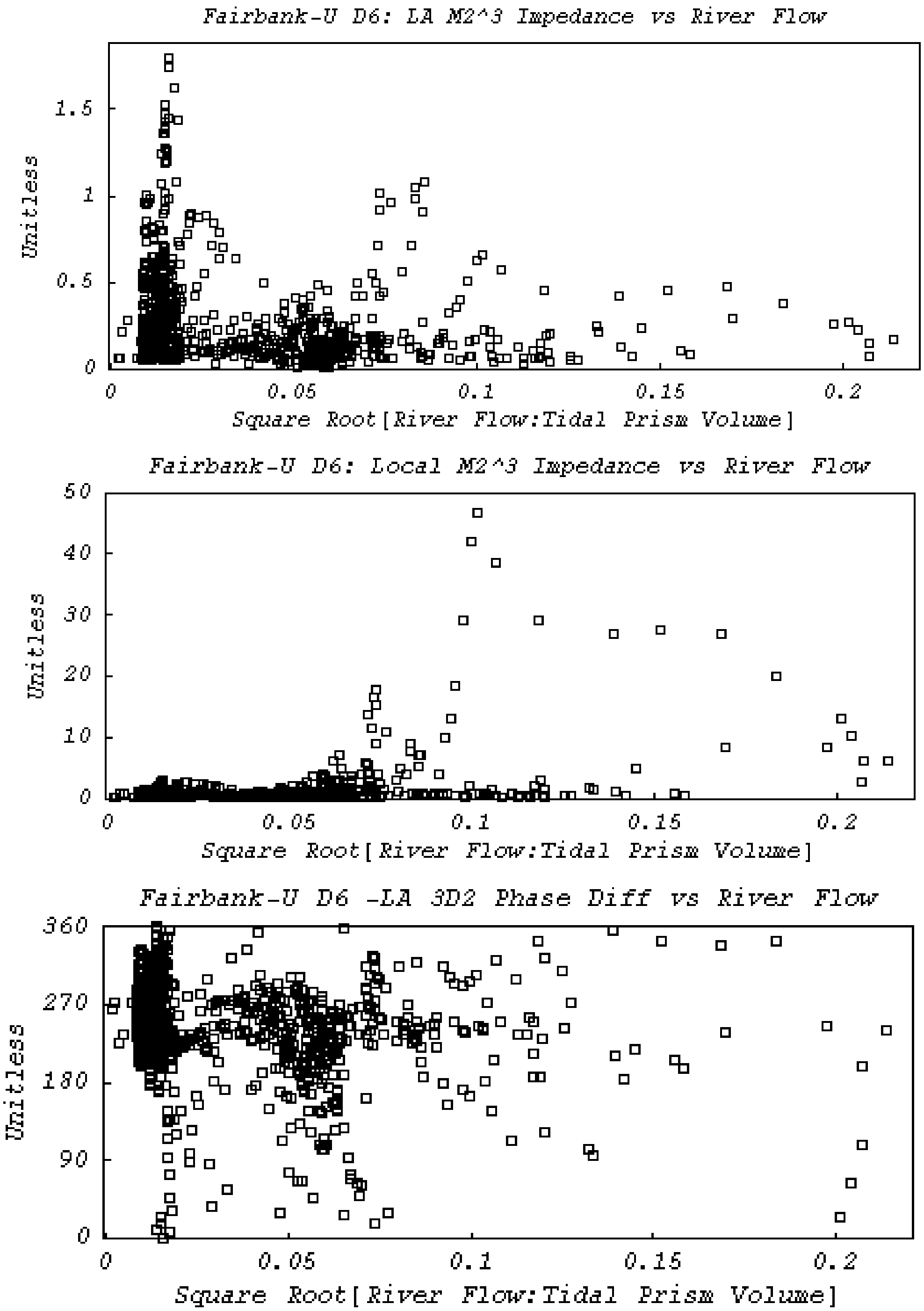


Figure 7.25: *Scatterplots of (top to bottom): PG&E:LA D_6 impedance amplitude, local D_6 impedance amplitude, and PG&E D_6 phase difference relative to LA vs. square root of the ratio of river flow to tidal prism.*

8. Summary of Conclusions

The possible impacts of the MBPP intake flow on tidal processes in Morro Bay have arisen as an issue in the Application for Certification process. The concern is that the MBPP intake flow might decrease the tidal prism and tidal exchange of the bay or in some other way affects tidal processes. If tidal processes were impacted by the MBPP, then the plant might have some role in the observed shoaling of the bay. This report describes analyses that evaluate the validity of this concern. To insure a rigorous and decisive result, the analyses are posed in terms of formal hypotheses, and state-of-the-art tidal analysis methods were used for hypothesis tests. The focus is on tidal processes (instead of sediment transport *per se*) because: a) tidal processes can be easily quantified, and b) any impacts on sediment transport must be a result of the physical circulation. If impacts on physical circulation are absent, then there can be no impacts on sediment transport.

The data analyses summarized below utilized two data sets:

- One month of tidal elevation data collected by Tetra Tech during March-April 1998 (Tetra Tech, 1999). Stations were located near the MBPP (station MBN) and in the interior of the bay (station MBS). Data from multiple locations is quite advantageous in understanding tidal dynamics.
- Data from a current meter deployed by PG&E near Fairbank Point between November 1995 and January 1997 (with a ~4 month gap between March and July 1996). Although data are available from only one location, the data set covers a large range of MBPP intake flow and river inflow. Furthermore, Fairbank Point is a crucial location – if no effects of the MBPP can be detected at Fairbank Point, then effects will also be absent at more landward points in back bay.

Two hypotheses were considered; the first hypothesis tested was:

H1: The daily tidal exchange and tidal prism of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

Hypothesis H1 was tested using the month of tidal elevation data collected by Tetra Tech in spring 1998. Results for H1 were negative, for both MBPP intake flow and river inflow. MBPP intake flow varied from ~150 to 360 MGD during the March-April 1998 period during which the Tetra Tech tidal elevation data were collected. This intake flow range corresponds to a range in the ratio of intake flow to tidal prism of ~1.2 to 4.2%. The total possible range of the ratio of intake flow to tidal prism is zero (no plant operation) to ~9% (full operation during the weakest neap tide). The range of plant operation that occurred during March-April 1998 did not produce any detectable perturbations to the tidal prism at station MBN (near the MBPP plant) or at station MBS (in the interior of the bay). The ratio of tidal range at station MBS to that at MBN was also unaffected. This test is not conclusive, because it covered only a portion of the total range of MBPP intake flow. The result achieved is, however, supported by analyses of tidal current data involving essentially the total range of MBPP intake flow, as described under Hypothesis H2, below. River flow into Morro Bay during the March-April 1998 period was only ~0.02 to 1% of the tidal prism. This is not high enough to produce any noticeable perturbation of the tides. Higher river flows in the range of 5-30% of the tidal prism do occur at intervals of ~6 mo to 5 yrs and do perturb the tides, thereby affecting sediment transport.

Hypothesis H1 was not tested with the 1995-97 current meter data, because there is no commonly accepted parameter that can be derived from current meter data analogous to tidal range, as derived from tidal elevation.

The second hypothesis tested was:

H2: Specific tidal species and tidal constituents of Morro Bay are measurably affected by the presence of mean flow processes in the bay: a) the MBPP intake flow and b) river inflow.

Results for H2a were negative for both the 1998 tidal elevation data and the 1995-97 current meter data. This negative outcome for the primary components of the tide (the diurnal [D_1] and semidiurnal or [D_2] tidal species) strongly reinforces the conclusions for H1, because the behavior of D_1 and D_2 waves governs the size of the tidal prism. Tests were also conducted for non-linearly generated overtides, because these are quite sensitive to non-tidal perturbations. These tests focused on the two largest overtides in the bay, the quarterdiurnal and six-diurnal species (D_4 and D_6). Also, specific predictions were available as to the reactions of D_4 and D_6 to the presence of a mean flow. If a mean flow actually influences tidal dynamics of a bay, it should cause D_4 to increase and D_6 to decrease, after normalization to the tide at a coastal reference station. If the D_4 and D_6 species are normalized to the local D_2 tide at the location of observations, then the overtide species should increase, because tidal energy is transferred from D_2 to the overtides as part of the process of frictional energy loss by D_2.

Results for Hypotheses H1a and H2a (the effects of MBPP intake flow on tidal processes in the bay) were consistent. No effects of MBPP operation were detectable in the interior of the bay (using both surface elevation and current data) or near the MBPP itself (where only surface elevation data were available). This test is conclusive in that the current meter data cover almost the entire range of MBPP intake flow, ~50 –612 MGD (compared to a total range of 0 – 668 MGD). This negative for Hypotheses H1a and H2a means that adverse effects of the MBPP intake flow on shoaling processes in the interior of the bay are excluded. It is not possible for the MBPP to affect sediment transport in the very shallow waters landward of Fairbank Point without acting through the tidal currents. This analysis does not, however, exclude the possibility that current data in the vicinity of the MBPP would reveal subtle effects on tidal exchange, sediment transport and currents near the estuary entrance.

There is a strong contrast between the negative results for Hypotheses H1a and H2a and the positive results for Hypotheses H2b (the effects of river inflow on tidal processes in the bay). The tidal dynamics of the bay respond strongly to river inflow – a decrease in tidal exchange was evident for river flow levels less than half of the maximum MBPP intake flow level. River inflow also strongly influences the sediment dynamics of the bay, both because high river inflow brings with it large amounts of sediment, and because river inflow changes the tidal dynamics and estuarine circulation of the bay in such a way as to favor sediment retention.

There is, furthermore, a clear physical reason why river inflow from Chorro and Los Osos Creeks affects Morro Bay's tidal dynamics in a way that MBPP intake flow does not. River inflow enters the bay in a shallow area that has weak tidal currents and is a considerable distance from the mouth. Thus, river flow affects the entire bay from the deltas to the ocean. River inflow causes, therefore, a substantial increase in bed friction throughout much of the bay. In contrast, the MBPP intake flow exists only in a small area between the MBPP and the mouth of the estuary. This part of the estuary is relatively deep and has much stronger tidal currents than most of the interior of the bay. The MBPP intake flow causes, therefore, only a relatively small increase in bed friction.

Finally, the analysis methods employed to test Hypotheses H1 and H2 were quite sensitive, as is evident from the positive results for Hypotheses H2b for relatively low river inflow levels (one-third of the two-year return flow). If there were adverse effects of the MBPP intake flow on the tidal dynamics of the interior of the bay, they would have been detected.

In summary, careful analyses of tidal properties during the 1995-98 period do not support the idea that MBPP intake flow has any effects, positive or negative, on the tidal regime, sediment transport or shoaling of Morro Bay. The data analyzed covered most of the dynamic range of the ratio of MBPP intake flow to tidal prism, but did not include periods with no plant operation. Since a negative outcome was achieved for periods of almost full plant operation, it is unlikely that the MBPP intake flow has any adverse effects on the sediment transport and shoaling processes of the interior of the bay at low operation levels. In contrast, river inflow was found to have very strong effects on the tidal properties of the bay. Not only do periods of strong river inflow provide large amounts of sediment to the bay, strong river inflow decreases tidal exchange and increases two-layer estuarine circulation in such a way as to foster retention of sediment. This retention of sediment is a natural process, but it has contributed to the shoaling of back bay.

9. <u>References</u>

Dronkers, J. J., 1964, Tidal Computations in Rivers and Coastal Waters, North-Holland, Amsterdam.

Dyer, K. R., 1997, *Estuaries, a Physical Introduction*, 2nd Ed, Wiley, New York.

Foreman, M. G. G., 1977, *Manual for Tidal Heights Analysis and Prediction*, Pacific Marine Science Report 77-10, Institute of Ocean Sciences, Patricia Bay, Victoria, B. C., 101 pp.

Friedrichs, C. T., and D. G. Aubrey, 1994, Tidal propagation in strongly convergent channels, *J. Geophys. Res*. 99: 3321-3336.

Gerdes, G. L., E. R. J. Primbs, and B. M. Browning, 1974, *Natural Resources of Morro Bay – Their Status and Future,* California Department of Fish and Game, Coastal Wetland Series #8.

Haltiner, J. and D. Thor, 1988, *Sedimentation processes in Morro Bay*, California, Phillip Williams and Associates, various paginations.

Haltiner, J. and D. Thor, 1991, *Sedimentation processes in Morro Bay*, California, Sedimentation and Physical Processes, ASCE Coastal Sediment Conference, Seattle, WA, pp. 7-1.1-7.1.21.

Flinchem, E. P. and D. A. Jay, 2000, An introduction to wavelet transform tidal analysis methods, *Coast. Estuar. Shelf Sci.* **51**: 177-200.

Jay, D. A., 1991, Green's law revisited: tidal long wave propagation in channels with strong topography. *J. Geophys. Res.* **96**: 20,585-20,598.

Jay, D. A. and Flinchem, E. P., 1997, Interaction of fluctuating river flow with a barotropic tide: A test of wavelet tidal analysis methods, *J. Geophys. Res.* **102**: 5705-5720.

Jay, D. A. and Flinchem, E. P., 1999, A comparison of methods for analysis of tidal records containing multi-scale non-tidal background energy, *Contin. Shelf Res*. **19**: 1695-1732.

Lanzoni and Seminara, 1998, On tide propagation in convergent estuaries, *J. Geophys. Res.* **103**: 30,793-30,812.

Orme, A. R., 1991, Evolution of the Morro barrier-lagoon system: a synthesis, ASCE Coastal Sediment Conference, Seattle, WA, pp. 7-3.39-7.3.48.

Parker, B. B., 1991, The relative importance of the various non-linear mechanisms in a wide range of tidal interactions, in: B. B. Parker (ed.), *Progress in Tidal Dynamics*, pp. 237-268, John Wiley, New York.

Tetra Tech, Inc., 1998, *Morro Bay National Estuary Program Sediment Loading Study*, Lafeyette, CA., various paginations.

Tetra Tech, Inc., 1999, *Morro Bay National Estuary Program Hydrodynamic Circulation Model*, Lafeyette, CA., various paginations.

10. Glossary

Baroclinic, **barotropic**: Barotropic currents are those caused by a slope of the water surface. Baroclinic currents are those caused by sloping density surfaces within a body of water.

Bedstress: The horizontal frictional force exerted on flowing water by the seabed.

Diurnal (**Semidiurnal**, **quarterdiurnal**, **six-diurnal**, etc): Tidal components with periods of about one day; semidiurnal for twice daily, etc.

Harmonic: Consisting of many different frequency components, each represented by a sinusoid with a frequency, amplitude and phase.

Impedance: The ratio of the complex numbers representing the amplitude and phase of a tidal species.

Intertidal: The region where wetting and drying of the seabed occurs due to tidal motions.

Mean flow: A net water movement; that is, a motion that can be seen in current data after the tidal motion has been averaged out. Such a current may have a zero value and may evolve slowly over time, e.g., over a tidal month of ~29.5 d.

MLLW, **MHHW**: Mean lower-low water or MLLW refers to the average (over a long period time) of the lowest water surface elevation of each tidal day. Mean higher-high water or MHHW is the average of the highest tides.

Neap-spring cycle: The "fortnightly" lunar cycle, with a period of about 15 days. Days with the smallest ranges are neap tides, those with the largest ranges are spring tides. There is typically a stronger and a weaker neap and a stronger and a waker spring tide during a tidal month of ~29.5 d.

Shoaling: Filling in with sediment; the opposite of erosion.

Subtidal: At a lower frequency lower than that of the diurnal; i.e., a motion having a period of 25 hours or longer.

Overtides: Non-linearly generated components of the tide that are generated upon propagation of a tide into shallow water, through interactions of the main tidal species. They can be defined by analysis of data or modeled from the fundamental equations governing tidal motion. Such non-linear tidal species or "overtides" are weak or absent in the open ocean.

Stationary and non-Stationary: A process is stationary, if its statistical properties are constant over time. In a non-stationary process, statistical properties vary over time. Since river flow and MBPP intake flow are irregular processes, they will, to the extent that they affect the tides in the bay, render them non-stationary.

Tidal constituent: One of the harmonic elements in a mathematical expression for the tide-producing force and in corresponding formulas for the tide or tidal current.

Tidal exchange: The volume of water that moves in and out of the mouth of the estuary to fill and empty the tidal prism.

Tidal-month: The 29.5-day lunar monthly tidal cycle, caused by orbit of the moon around the earth.

Tidal prism: Volume between the MLLW and MHHW datum levels.

Tidal range: Height between the lowest and highest tides of the day.

Tidal species: Major components of the astronomical tide. Each tidal species has a mathematical representation, in terms of a complex number with time-variable amplitude and phase.

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Appendix F

Entrainment and Source Water Larval Fish and Megalopal Cancer Crab Results

Table F-1. Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	**Common Name**	**Total All Surveys**	Survey 1 June 21-22, 1999 N = 12		Survey 2 June 28-29 N = 12		Survey 3 July 8-9 N = 12		Survey 4 July 14-15 N = 12		Survey 5 July 19-20 N = 12		Survey 6 July 30-31 N = 12		Survey 7 Aug. 3-4 N = 12		Survey 8 Aug. 9-10 N = 12	
			Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	26,703	753	1157.1	406	757.3	489	925.2	420	664.1	386	712.4	258	420.0	156	244.4	520	699.0
Hypsoblennius spp.	blennies	1,991	49	75.9	45	78.9	112	225.3	207	338.6	170	357.1	485	766.6	252	398.1	99	145.1
Leptocottus armatus	Pacific staghorn sculpin	1,896	-	-	-	-	-	-	-	-	1	2.0	-	-	1	1.3	-	-
Stenobrachius leucopsarus	northern lampfish	1,048	-	-	-	-	1	1.4	-	-	-	-	-	-	-	-	-	-
Eucyclogobius newberryi	tidewater goby	992	-	-	29	47.2	8	12.5	48	82.8	3	5.7	13	23.8	-	-	46	55.9
Coryphopterus nicholsi	blackeye goby	515	13	20.3	15	24.7	6	13.3	72	118.6	24	48.2	95	153.8	37	60.7	27	31.7
Atherinopsis californiensis	jacksmelt	396	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	384	-	-	1	1.8	27	55.3	6	10.0	1	2.3	1	1.3	1	1.5	6	8.7
Sebastes spp. V_De	rockfishes	360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupea pallasii	Pacific herring	277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	242	2	2.8	10	20.0	5	11.0	1	1.6	2	4.0	1	1.9	1	1.7	29	36.5
Genyonemus lineatus	white croaker	238	-	-	-	-	1	1.4	-	-	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	222	3	4.8	7	11.8	8	14.4	10	15.8	-	-	4	7.5	-	-	37	42.1
Lepidogobius lepidus	bay goby	200	-	-	3	6.5	1	2.0	2	3.1	-	-	6	8.7	4	6.0	1	1.5
Atherinidae unid.	silversides	187	-	-	1	1.8	11	19.1	5	8.6	-	-	-	-	1	1.6	6	7.9
Engraulis mordax	northern anchovy	175	-	-	1	1.4	1	1.6	2	3.8	6	11.4	-	-	1	1.6	5	6.3
Scorpaenichthys marmoratus	cabezon	174	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarletonbeania crenularis	blue lanternfish	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	103	-	-	1	1.5	-	-	-	-	-	-	-	-	1	1.5	-	-
Bathymasteridae unid.	ronquils	82	1	1.5	2	3.1	-	-	10	17.5	1	1.8	-	-	-	-	1	1.6
larval fish - damaged	unidentified larval fishes	79	-	-	-	-	2	4.7	-	-	1	1.7	1	1.1	-	-	-	-
Cottidae unid.	sculpins	75	-	-	3	4.4	1	2.0	5	7.9	-	-	1	1.5	-	-	2	2.9
Chaenopsidae unid.	tube blennies	57	2	3.4	2	3.9	2	3.9	2	3.3	-	-	9	13.6	4	5.9	5	6.7
Stichaeidae unid.	pricklebacks	53	-	-	2	3.1	-	-	2	3.4	-	-	-	-	-	-	2	2.8
Artedius lateralis	smoothhead sculpin	47	-	-	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus spp.	sculpins	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cebidichthys violaceus	monkeyface eel	33	-	-	2	3.5	3	4.2	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	31	2	3.0	3	6.3	-	-	3	5.4	-	-	1	1.8	-	-	2	2.7
Bathylagus ochotensis	popeye blacksmelt	29	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	28	-	-	3	5.2	-	-	-	-	-	-	1	1.3	1	1.5	1	1.5
Artedius spp.	sculpins	27	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinocottus analis	wooly sculpin	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	25	-	-	1	2.1	-	-	1	1.9	-	-	2	3.5	-	-	1	1.0
Liparis spp.	snailfishes	24	-	-	-	-	1	2.3	-	-	-	-	-	-	-	-	1	1.6
Osmeridae unid.	smelts	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	20	1	1.6	2	2.8	-	-	1	1.9	-	-	1	1.5	-	-	-	-
Syngnathus spp.	pipefishes	20	-	-	-	-	-	-	-	-	1	2.0	-	-	-	-	-	-
Pleuronectidae unid.	flounders	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platichthys stellatus	starry flounder	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammodytes hexapterus	Pacific sand lance	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blennioidei	blennies	11	2	3.0	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholididae unid.	gunnels	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	9	-	-	-	-	1	2.0	1	1.9	-	-	-	-	1	1.8	3	3.5

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

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			Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croaker	7	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	6	-	-	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	6	-	-	-	-	-	-	-	-	4	7.8	-	-	-	-	-	-
Cottus asper	prickly sculpin	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_	rockfishes	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis *frenata*	shortspine combfish	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	37,434	830		542		681		799		600		879		461		794	
Crabs																		
Cancer antennarius (megalops)	brown rock crab	564	-	-	-	-	-	-	-	-	-	-	1	1.8	1	1.8	-	-
Cancer jordani (megalops)	hairy rock crab	116	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-
Cancer anthonyi (megalops)	yellow rock crab	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.0
Cancer gracilis (megalops)	slender rock crab	31	2	3.1	-	-	-	-	-	-	-	-	-	-	2	3.3	-	-
Carcinus maenas (megalops)	European green crab	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	14	11	16.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	10	4	5.9	-	-	1	1.4	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	9	-	-	-	-	-	-	1	1.9	-	-	-	-	-	-	-	-
	Total:	845	17		0		1		2		0		1		3		1	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 9 Dec. 14-15 N = 11		Survey 10 Dec. 20-21 N = 12		Survey 11 Dec. 28-29 N = 12		Survey 12 Jan. 3-4, 2000 N = 12		Survey 13 Jan. 10-11 N = 12		Survey 14 Jan. 17-18 N = 12		Survey 15 Jan. 24-25 N = 12		Survey 16 Jan. 31-Feb. 1 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	351	539.9	518	664.9	75	112.1	117	182.2	211	328.4	333	519.8	263	459.1	433	569.0
Hypsoblennius spp.	blennies	-	-	-	-	-	-	-	-	-	-	2	3.3	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	765	1263.1	55	94.0	26	40.5	144	210.7	105	164.3	25	38.6	35	59.4	14	22.6
Stenobrachius leucopsarus	northern lampfish	29	50.3	85	145.0	11	14.8	569	921.0	50	72.6	27	40.8	10	15.5	2	3.0
Eucyclogobius newberryi	tidewater goby	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coryphopterus nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinopsis californiensis	jacksmelt	12	20.2	2	3.7	1	1.3	32	46.2	128	196.8	7	10.1	43	68.1	27	41.4
larval fish fragment	unidentified larval fishes	3	4.7	4	5.6	-	-	9	14.1	6	8.6	2	2.9	19	30.5	6	9.0
Sebastes spp. V_De	rockfishes	-	-	-	-	1	1.6	1	1.6	-	-	1	1.7	3	4.4	1	1.5
Clupea pallasii	Pacific herring	35	53.8	12	20.3	2	3.1	2	3.2	-	-	6	9.2	1	1.4	-	-
Gillichthys mirabilis	longjaw mudsucker	5	8.0	6	8.0	-	-	2	3.3	6	9.2	3	5.2	-	-	-	-
Genyonemus lineatus	white croaker	3	5.5	1	2.1	54	69.6	8	12.2	1	1.3	2	3.5	26	43.4	17	26.3
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-	1	1.7
Lepidogobius lepidus	bay goby	2	3.1	1	1.2	-	-	2	3.6	-	-	3	4.7	2	3.7	-	-
Atherinidae unid.	silversides	-	-	4	5.6	2	3.3	13	18.2	20	33.5	2	3.5	1	2.0	2	2.8
Engraulis mordax	northern anchovy	4	7.4	5	8.0	22	29.5	14	24.0	11	17.7	2	3.2	1	2.0	-	-
Scorpaenichthys marmoratus	cabezon	2	3.2	-	-	3	4.2	8	13.1	7	10.2	15	23.1	5	7.7	27	43.2
Sebastes spp. V	rockfishes	-	-	-	-	7	10.5	5	7.5	2	2.9	6	8.5	110	172.4	6	9.7
Tarletonbeania crenularis	blue lanternfish	1	1.8	6	11.0	-	-	63	99.2	2	3.0	1	1.3	2	3.3	-	-
Gibbonsia spp.	clinid kelpfishes	3	4.7	-	-	28	43.4	6	8.8	-	-	1	1.6	2	3.0	2	3.3
Bathymasteridae unid.	ronquils	-	-	-	-	-	-	-	-	-	-	-	-	5	7.5	3	4.2
larval fish - damaged	unidentified larval fishes	1	1.6	-	-	-	-	1	1.3	-	-	1	1.8	9	14.6	-	-
Cottidae unid.	sculpins	4	6.4	-	-	1	1.6	2	3.1	-	-	-	-	1	2.0	1	1.2
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stichaeidae unid.	pricklebacks	6	12.0	-	-	5	7.2	5	6.8	1	1.6	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3.2
Sebastes spp. VD	rockfishes	2	3.5	12	22.6	11	16.6	6	8.7	3	4.6	-	-	3	4.6	4	6.5
Oligocottus spp.	sculpins	1	1.3	1	2.1	2	2.7	3	4.5	1	1.6	-	-	-	-	3	4.2
Cebidichthys violaceus	monkeyface eel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	2	3.1	-	-
Bathylagus ochotensis	popeye blacksmelt	-	-	-	-	-	-	1	1.7	-	-	-	-	3	4.6	-	-
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	1	1.5	-	-
Clinocottus analis	wooly sculpin	-	-	-	-	-	-	2	3.2	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4.9
Liparis spp.	snailfishes	-	-	-	-	3	4.2	-	-	-	-	-	-	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6	1	1.2
Pleuronectidae unid.	flounders	-	-	-	-	3	4.2	1	1.9	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	1	1.7	-	-	1	1.6	-	-	-	-	-	-	3	4.6	-	-
Hexagrammidae unid.	greenlings	-	-	3	5.4	3	4.8	-	-	-	-	1	1.6	-	-	1	1.6
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	18.2
Citharichthys sordidus	Pacific sanddab	1	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	1	1.2	-	-	-	-	-	-	-	-	-	-
Blennioidei	blennies	-	-	-	-	1	1.6	1	1.8	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-	1	1.5
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 9 Dec. 14-15 N = 11		Survey 10 Dec. 20-21 N = 12		Survey 11 Dec. 28-29 N = 12		Survey 12 Jan. 3-4, 2000 N = 12		Survey 13 Jan. 10-11 N = 12		Survey 14 Jan. 17-18 N = 12		Survey 15 Jan. 24-25 N = 12		Survey 16 Jan. 31-Feb. 1 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	1	1.6	-	-	-	-	-	-	2	2.9	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	2	5.8	-	-	2	2.9	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	4	6.2	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	1	1.9	1	1.5	-	-	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	1	1.5	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	1	1.7	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	1	1.3	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,233		716		273		1,019		558		442		553		570	
Crabs																	
Cancer antennarius (megalops)	brown rock crab	-	-	1	1.7	2	2.5	2	2.9	2	3.4	-	-	-	-	-	-
Cancer jordani (megalops)	hairy rock crab	-	-	1	1.5	-	-	2	3.0	7	9.1	3	5.1	1	1.4	-	-
Cancer anthonyi (megalops)	yellow rock crab	4	6.1	-	-	2	2.3	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (megalops)	slender rock crab	1	1.4	-	-	-	-	1	1.7	4	5.8	2	3.0	-	-	2	3.4
Carcinus maenas (megalops)	European green crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	5		2		4		5		13		5		1		2	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 17 Feb. 7-8 N = 12		Survey 18 Feb. 14-15 N = 12		Survey 19 Feb. 21-22 N = 12		Survey 20 Feb. 28-29 N = 12		Survey 21 March 6-7 N = 12		Survey 22 March 13-14 N = 12		Survey 23 March 20-21 N = 12		Survey 24 March 27-28 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	442	750.5	858	1531.7	731	1348.0	603	905.0	623	783.8	473	646.3	625	963.3	668	1154.7
Hypsoblennius spp.	blennies	3	4.9	-	-	-	-	-	-	-	-	-	-	-	-	3	5.0
Leptocottus armatus	Pacific staghorn sculpin	71	115.5	6	9.8	1	1.6	14	19.8	3	4.0	5	6.8	9	13.8	51	82.6
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	1	1.7	6	8.0	7	9.2	33	44.7	13	19.1	6	9.6
Eucyclogobius newberryi	tidewater goby	-	-	8	14.7	1	1.6	13	19.6	16	19.6	1	1.3	4	6.1	10	18.5
Coryphopterus nicholsi	blackeye goby	-	-	-	-	-	-	-	-	-	-	1	1.5	1	1.7	1	1.9
Atherinopsis californiensis	jacksmelt	23	34.7	15	27.5	-	-	16	22.4	4	5.0	31	42.1	-	-	12	21.5
larval fish fragment	unidentified larval fishes	-	-	19	32.2	1	1.7	24	34.9	11	13.8	3	3.8	-	-	2	3.6
Sebastes spp. V_De	rockfishes	-	-	-	-	8	10.5	1	1.3	17	22.7	-	-	15	26.3	-	-
Clupea pallasii	Pacific herring	-	-	4	6.6	2	3.2	-	-	-	-	-	-	1	1.6	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	-	-	1	2.1	-	-	4	4.9	-	-	4	6.2	2	3.2
Genyonemus lineatus	white croaker	5	8.1	10	15.4	2	3.2	-	-	1	1.4	-	-	-	-	16	28.5
Atherinops affinis	topsmelt	1	1.7	-	-	-	-	-	-	6	7.2	-	-	1	1.4	4	7.2
Lepidogobius lepidus	bay goby	2	3.4	1	1.9	-	-	-	-	-	-	-	-	-	-	1	1.9
Atherinidae unid.	silversides	24	42.3	11	18.3	1	1.6	-	-	1	1.2	4	5.1	-	-	1	1.9
Engraulis mordax	northern anchovy	1	1.9	-	-	-	-	-	-	4	5.0	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	5	7.9	34	57.8	-	-	4	5.7	4	5.3	8	11.7	-	-	3	5.3
Sebastes spp. V	rockfishes	-	-	2	3.5	1	1.7	1	1.3	-	-	-	-	-	-	-	-
Tarletonbeania crenularis	blue lanternfish	-	-	-	-	-	-	-	-	1	1.4	4	5.7	3	4.3	10	17.5
Gibbonsia spp.	clinid kelpfishes	8	12.3	1	2.0	3	4.5	6	8.9	9	11.6	2	2.5	4	6.3	1	1.9
Bathymasteridae unid.	ronquils	2	3.4	2	3.7	6	8.9	-	-	1	1.1	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	7	12.5	-	-	1	1.7	-	-	3	3.6	2	2.6	1	1.3	-	-
Cottidae unid.	sculpins	1	2.0	-	-	5	9.4	2	3.2	3	4.3	-	-	-	-	1	1.6
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-	-	-
Stichaeidae unid.	pricklebacks	1	1.6	11	20.4	1	2.1	-	-	-	-	1	1.2	1	1.7	5	7.2
Artedius lateralis	smoothhead sculpin	-	-	-	-	9	12.3	1	1.5	-	-	1	1.2	1	1.7	-	-
Sebastes spp. VD	rockfishes	2	3.6	-	-	1	2.1	-	-	-	-	-	-	1	1.6	-	-
Oligocottus spp.	sculpins	1	1.9	-	-	2	3.6	3	5.1	5	6.7	2	3.0	-	-	1	1.5
Cebidichthys violaceus	monkeyface eel	-	-	-	-	1	2.1	-	-	1	1.4	-	-	5	9.5	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathylagus ochotensis	popeye blacksmelt	-	-	-	-	-	-	-	-	1	1.5	-	-	2	3.6	-	-
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	1	2.1	-	-	-	-	-	-	2	3.1	-	-
Artedius spp.	sculpins	4	6.4	1	1.5	1	1.9	-	-	2	2.8	2	2.8	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	-	-	1	2.1	1	1.8	1	1.3	1	1.3	1	1.6	-	-
Oxylebius pictus	painted greenling	-	-	-	-	1	1.0	1	1.5	-	-	-	-	-	-	-	-
Liparis spp.	snailfishes	1	1.7	1	1.3	2	3.8	-	-	-	-	-	-	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	1	1.3	15	20.3	1	1.4	5	7.0	1	1.8
Ruscarius creaseri	rouchcheek sculpin	1	1.6	1	1.9	1	1.6	1	1.8	-	-	1	1.8	1	1.8	-	-
Syngnathus spp.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	1	1.5	-	-	-	-	1	1.4	3	4.0	-	-	2	3.2
Orthonopias triacis	snubnose sculpin	-	-	1	2.0	6	10.8	1	1.4	-	-	-	-	-	-	-	-
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	3	5.0	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-
Ammodytes hexapterus	Pacific sand lance	1	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	1	1.4	-	-
Blennioidei	blennies	-	-	1	1.7	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	1	1.9	-	-	-	-	-	-	6	7.2	-	-	-	-	1	1.4
Pholididae unid.	gunnels	-	-	1	1.9	1	1.9	3	4.5	2	2.6	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 17 Feb. 7-8 N = 12		Survey 18 Feb. 14-15 N = 12		Survey 19 Feb. 21-22 N = 12		Survey 20 Feb. 28-29 N = 12		Survey 21 March 6-7 N = 12		Survey 22 March 13-14 N = 12		Survey 23 March 20-21 N = 12		Survey 24 March 27-28 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	-	-	3	4.1	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	2	2.9	-	-	-	-	-	-	2	3.8
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	2	3.1	-	-	1	2.1	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	3	3.6	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	1	1.8	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3.7
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	612		989		794		706		759		579		703		807	
Crabs																	
Cancer *antennarius* (megalops)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer *jordani* (megalops)	hairy rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (megalops)	yellow rock crab	1	1.6	-	-	-	-	-	-	1	1.2	-	-	-	-	-	-
Cancer gracilis (megalops)	slender rock crab	-	-	-	-	7	11.6	-	-	1	1.4	-	-	-	-	1	1.9
Carcinus maenas (megalops)	European green crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1		0		7		0		2		0		0		1	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 25 April 3-4 N = 12		Survey 26 April 10-11 N = 12		Survey 27 April 18-19 N = 12		Survey 28 April 24-25 N = 12		Survey 29 May 1-2 N = 12		Survey 30 May 8-9 N = 11		Survey 31 May 15-16 N = 12		Survey 32 May 22-23 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	915	1483.1	200	312.2	749	1190.8	333	489.8	1,002	1525.1	484	778.9	406	643.4	1,623	2788.5
Hypsoblennius spp.	blennies	-	-	-	-	-	-	-	-	-	-	2	3.1	1	1.9	6	10.1
Leptocottus armatus	Pacific staghorn sculpin	80	128.2	79	128.3	52	84.8	88	126.7	8	10.6	4	6.0	6	9.4	4	7.2
Stenobrachius leucopsarus	northern lampfish	135	224.5	3	4.8	15	20.6	21	29.2	3	3.7	2	2.8	1	1.6	-	-
Eucyclogobius newberryi	tidewater goby	11	16.9	29	49.4	2	3.0	17	25.0	27	42.8	23	39.0	32	50.2	15	26.2
Coryphopterus nicholsi	blackeye goby	1	1.4	1	1.6	1	1.8	7	10.7	1	1.6	6	8.4	2	2.8	4	6.3
Atherinopsis californiensis	jacksmelt	-	-	5	8.0	-	-	2	3.2	-	-	-	-	-	-	1	1.3
larval fish fragment	unidentified larval fishes	27	46.2	16	26.1	1	1.5	1	1.6	24	36.3	10	16.0	18	29.4	2	3.3
Sebastes spp. V_De	rockfishes	17	29.4	15	23.0	200	332.7	16	23.5	6	8.0	18	27.4	2	2.8	28	51.5
Clupea pallasii	Pacific herring	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	1	1.7	-	-	4	6.9	-	-	4	6.5	1	1.2	4	6.1	1	1.6
Genyonemus lineatus	white croaker	10	17.5	8	12.3	-	-	1	1.4	-	-	-	-	-	-	-	-
Atherinops affinis	topsmelt	1	1.4	4	7.4	1	1.4	7	11.1	36	51.6	31	53.8	7	10.4	12	19.7
Lepidogobius lepidus	bay goby	-	-	-	-	-	-	-	-	2	2.8	2	2.8	-	-	1	1.7
Atherinidae unid.	silversides	3	5.0	-	-	-	-	2	3.1	5	8.1	8	11.8	6	9.4	1	1.7
Engraulis mordax	northern anchovy	3	5.1	6	10.1	2	3.0	-	-	-	-	1	1.3	-	-	3	5.6
Scorpaenichthys marmoratus	cabezon	2	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	2	3.5	-	-	-	-	-	-	-	-	1	4.0	1	1.4	-	-
Tarletonbeania crenularis	blue lanternfish	42	68.9	1	1.4	-	-	2	2.7	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	-	-	7	11.2	-	-	-	-	-	-	-	-	-	-
Bathymasteridae unid.	ronquils	3	5.0	4	6.3	-	-	1	1.5	10	12.6	3	7.3	-	-	7	11.7
larval fish - damaged	unidentified larval fishes	3	5.2	1	1.5	-	-	-	-	13	19.0	2	2.8	-	-	-	-
Cottidae unid.	sculpins	5	8.7	1	1.5	1	1.5	2	2.9	3	4.1	3	4.2	5	7.9	4	7.1
Chaenopsidae unid.	tube blennies	1	2.1	-	-	-	-	-	-	-	-	6	9.3	-	-	3	5.3
Stichaeidae unid.	pricklebacks	-	-	-	-	2	2.9	2	2.6	1	1.2	1	1.4	1	1.9	-	-
Artedius lateralis	smoothhead sculpin	1	1.8	-	-	6	8.9	1	1.4	10	13.3	1	4.0	-	-	5	8.3
Sebastes spp. VD	rockfishes	-	-	-	-	1	1.8	-	-	-	-	-	-	-	-	-	-
Oligocottus spp.	sculpins	-	-	-	-	3	5.1	1	1.4	-	-	1	1.6	4	5.5	2	3.7
Cebidichthys violaceus	monkeyface eel	3	5.1	-	-	2	3.1	3	4.2	4	5.6	-	-	5	7.6	3	5.6
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	3	4.7	-	-	3	5.3
Bathylagus ochotensis	popeye blacksmelt	5	8.1	-	-	2	2.8	1	1.3	-	-	4	8.2	2	3.1	4	7.0
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	-	-	1	1.6	1	1.7	-	-	9	15.9	2	3.2
Artedius spp.	sculpins	1	1.4	-	-	-	-	-	-	1	1.4	-	-	-	-	10	17.4
Clinocottus analis	wooly sculpin	2	3.4	1	1.4	1	1.5	-	-	1	1.6	1	1.3	2	2.4	3	5.4
Oxylebius pictus	painted greenling	-	-	-	-	1	1.8	-	-	-	-	-	-	-	-	-	-
Liparis spp.	snailfishes	-	-	-	-	-	-	3	4.3	1	1.2	-	-	-	-	3	5.3
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-	2	4.1
Syngnathus spp.	pipefishes	-	-	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	2	3.4	-	-	2	3.2	2	2.9	1	1.3	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.7
Platichthys stellatus	starry flounder	-	-	7	11.4	-	-	8	11.6	1	1.3	-	-	-	-	-	-
Sebastes spp.	rockfishes	1	1.8	-	-	5	8.0	-	-	-	-	2	2.8	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	1	1.4	-	-	-	-	-	-	6	11.6
Blennioidei	blennies	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 25 April 3-4 N = 12 Ct.	Conc.	Survey 26 April 10-11 N = 12 Ct.	Conc.	Survey 27 April 18-19 N = 12 Ct.	Conc.	Survey 28 April 24-25 N = 12 Ct.	Conc.	Survey 29 May 1-2 N = 12 Ct.	Conc.	Survey 30 May 8-9 N = 11 Ct.	Conc.	Survey 31 May 15-16 N = 12 Ct.	Conc.	Survey 32 May 22-23 N = 12 Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	1	1.4	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	4	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	3	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	1	1.7	-	-	2	3.0	1	1.5	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	1	1.2	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	2	4.1	-	-	-	-	-	-	1	1.2	-	-	-	-	1	1.9
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	1	1.8	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	3	3.6	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	2	3.2	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,289		383		1,065		526		1,172		621		515		1,760	
Crabs																	
Cancer antennarius (megalops)	brown rock crab	-	-	4	6.0	2	3.3	5	7.3	6	8.6	24	40.4	3	4.1	8	14.3
Cancer jordani (megalops)	hairy rock crab	10	17.8	30	45.3	5	8.1	2	2.9	4	6.0	5	8.6	-	-	3	5.0
Cancer anthonyi (megalops)	yellow rock crab	-	-	1	1.5	2	3.0	-	-	1	1.6	-	-	-	-	1	1.7
Cancer gracilis (megalops)	slender rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carcinus maenas (megalops)	European green crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	2	3.3	1	1.7
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
	Total:	10		35		9		7		12		29		5		13	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 33 May 30-31 N = 12		Survey 34 June 5-6 N = 12		Survey 35 June 12-13 N = 12		Survey 36 June 19-20 N = 11		Survey 37 June 26-27 N = 12		Survey 38 July 3-4 N = 12		Survey 39 July 10-11 N = 12		Survey 40 July 17-18 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	1,207	1768.3	752	991.8	205	309.4	471	800.1	744	1074.3	223	368.7	185	271.2	323	516.4
Hypsoblennius spp.	blennies	2	3.7	4	6.0	4	6.6	46	67.5	45	80.0	24	40.9	36	53.7	70	105.6
Leptocottus armatus	Pacific staghorn sculpin	-	-	6	8.8	-	-	-	-	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	1	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Eucyclogobius newberryi	tidewater goby	147	197.8	182	217.1	2	2.8	8	14.2	14	20.1	47	82.2	6	8.6	20	30.2
Coryphopterus nicholsi	blackeye goby	3	5.0	4	5.5	2	3.2	9	15.0	6	11.3	5	7.2	19	27.4	4	6.6
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-
larval fish fragment	unidentified larval fishes	22	32.0	16	20.8	1	1.2	5	7.2	8	13.7	1	1.6	4	5.7	-	-
Sebastes spp. V_De	rockfishes	3	4.4	7	9.9	-	-	-	-	-	-	-	-	-	-	-	-
Clupea pallasii	Pacific herring	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	11	15.8	4	4.6	3	4.7	1	1.4	2	2.8	2	3.5	-	-	2	3.1
Genyonemus lineatus	white croaker	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-
Atherinops affinis	topsmelt	23	33.4	7	10.4	-	-	1	2.5	3	4.3	2	3.7	2	2.9	-	-
Lepidogobius lepidus	bay goby	-	-	-	-	-	-	-	-	5	7.7	-	-	-	-	-	-
Atherinidae unid.	silversides	8	11.6	14	21.5	2	3.0	-	-	2	2.9	3	5.5	-	-	-	-
Engraulis mordax	northern anchovy	-	-	-	-	-	-	-	-	2	2.9	34	55.7	1	1.4	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarletonbeania crenularis	blue lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	2	2.4	-	-
Gibbonsia spp.	clinid kelpfishes	2	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathymasteridae unid.	ronquils	-	-	5	8.6	8	11.3	1	1.5	-	-	-	-	2	3.1	-	-
larval fish - damaged	unidentified larval fishes	3	4.9	2	2.3	-	-	-	-	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	1.7	1	1.1	1	1.9	1	1.4	5	7.5	3	4.6	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	-	-	-	-	-	-	1	1.6	3	4.5	-	-
Stichaeidae unid.	pricklebacks	-	-	-	-	2	2.5	-	-	-	-	1	1.9	-	-	-	-
Artedius lateralis	smoothhead sculpin	1	1.7	2	2.6	2	3.4	1	1.4	1	1.4	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2.8
Cebidichthys violaceus	monkeyface eel	-	-	1	1.9	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	1.6	2	2.7	1	1.7	-	-	-	-	-	-	-	-	-	-
Bathylagus ochotensis	popeye blacksmelt	-	-	2	3.2	1	1.7	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	1	1.8	-	-	-	-	1	2.0	1	1.4	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	1	1.7	-	-	2	2.7	-	-	-	-	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	1	1.3	-	-	3	4.1	-	-	-	-	1	1.8	2	3.5
Oxylebius pictus	painted greenling	1	1.7	-	-	1	1.5	-	-	-	-	4	6.3	-	-	1	1.8
Liparis spp.	snailfishes	-	-	-	-	1	1.7	-	-	-	-	1	1.6	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	1	1.7	-	-	-	-	3	4.1	-	-	-	-	-	-	1	1.5
Syngnathus spp.	pipefishes	-	-	-	-	-	-	1	1.5	-	-	-	-	2	2.6	-	-
Pleuronectidae unid.	flounders	-	-	-	-	1	1.9	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	1	1.3	-	-	1	1.5	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2.4
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	3	4.6	-	-	-	-	-	-	-	-
Blennioidei	blennies	-	-	-	-	2	3.0	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 33 May 30-31 N = 12 Ct.	 Conc.	Survey 34 June 5-6 N = 12 Ct.	 Conc.	Survey 35 June 12-13 N = 12 Ct.	 Conc.	Survey 36 June 19-20 N = 11 Ct.	 Conc.	Survey 37 June 26-27 N = 12 Ct.	 Conc.	Survey 38 July 3-4 N = 12 Ct.	 Conc.	Survey 39 July 10-11 N = 12 Ct.	 Conc.	Survey 40 July 17-18 N = 12 Ct.	 Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	1	1.2	-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	1	1.7	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	1	1.2	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	1	1.2	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	1	1.2	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	1	1.2	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.2
Ruscarius spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	1,438		1,015		239		558		840		356		264		428	
Crabs																	
Cancer antennarius (megalops)	brown rock crab	77	124.8	358	565.6	26	41.8	9	13.8	5	7.3	4	5.5	-	-	1	1.3
Cancer jordani (megalops)	hairy rock crab	2	3.1	14	23.6	1	1.7	2	3.0	2	2.4	3	5.4	1	1.6	1	1.4
Cancer anthonyi (megalops)	yellow rock crab	2	3.3	4	5.8	2	3.1	1	1.4	-	-	6	9.8	-	-	-	-
Cancer gracilis (megalops)	slender rock crab	-	-	-	-	1	1.1	-	-	-	-	-	-	-	-	-	-
Carcinus maenas (megalops)	European green crab	-	-	1	1.3	-	-	-	-	-	-	-	-	-	-	-	-
Cancer *magister* (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	1	1.5	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	-	-	2	3.4	1	1.7	-	-	-	-	1	1.8	-	-	-	-
	Total:	81		379		31		13		7		14		1		2	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 41 July 24-25 N = 12		Survey 42 July 31-Aug. 1 N = 12		Survey 43 Aug. 8-9 N = 12		Survey 44 Aug. 14-15 N = 12		Survey 45 Aug. 21-22 N = 12		Survey 46 Aug. 28-29 N = 12		Survey 47 Sept. 5-6 N = 12		Survey 48 Sept. 11-12 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	294	373.8	69	108.1	160	256.9	810	1319.4	31	48.3	97	152.3	110	181.3	366	561.4
Hypsoblennius spp.	blennies	73	110.6	19	30.2	57	97.9	21	31.4	51	84.5	13	19.8	36	58.5	15	23.1
Leptocottus armatus	Pacific staghorn sculpin	1	1.7	-	-	2	3.5	-	-	-	-	1	1.3	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eucyclogobius newberryi	tidewater goby	11	13.8	-	-	33	55.3	140	215.8	4	6.8	5	8.3	4	6.8	6	9.4
Coryphopterus nicholsi	blackeye goby	23	30.1	15	23.5	5	8.1	8	11.4	16	26.4	2	3.3	3	5.1	16	24.4
Atherinopsis californiensis	jacksmelt	-	-	-	-	1	1.8	-	-	-	-	-	-	-	-	-	-
larval fish fragment	unidentified larval fishes	-	-	4	6.7	8	13.4	10	14.8	-	-	2	3.5	2	3.1	1	1.5
Sebastes spp. V_De	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupea pallasii	Pacific herring	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	4	6.8	-	-	4	5.8	1	1.6	5	8.2	-	-	16	25.3
Genyonemus lineatus	white croaker	-	-	-	-	-	-	5	7.6	-	-	1	1.3	1	1.6	-	-
Atherinops affinis	topsmelt	-	-	2	3.1	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	3	4.1	2	3.8	9	15.9	14	23.3	7	9.5	-	-	1	1.6	4	6.1
Atherinidae unid.	silversides	-	-	3	5.0	1	1.6	1	1.5	5	8.6	-	-	-	-	-	-
Engraulis mordax	northern anchovy	-	-	-	-	-	-	2	2.8	2	3.1	-	-	1	1.6	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tarletonbeania crenularis	blue lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathymasteridae unid.	ronquils	-	-	1	1.5	-	-	-	-	-	-	3	4.3	-	-	-	-
larval fish - damaged	unidentified larval fishes	-	-	1	1.5	-	-	3	5.7	-	-	5	8.3	3	5.2	1	1.4
Cottidae unid.	sculpins	-	-	-	-	-	-	2	2.6	1	1.6	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	2	2.5	-	-	1	1.6	1	2.1	-	-	1	2.0	2	3.5	-	-
Stichaeidae unid.	pricklebacks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus spp.	sculpins	-	-	1	1.6	-	-	-	-	1	1.6	-	-	-	-	-	-
Cebidichthys violaceus	monkeyface eel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	1	1.5	3	4.6	-	-	-	-	-	-	2	3.1	-	-	-	-
Bathy*lagus ochotensis*	popeye blacksmelt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-	-	-
Liparis spp.	snailfishes	1	1.2	-	-	-	-	-	-	4	6.1	-	-	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	1	1.2	-	-	2	2.8	2	3.6	-	-	-	-	2	3.3	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blennioidei	blennies	1	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 41 July 24-25 N = 12		Survey 42 July 31-Aug. 1 N = 12		Survey 43 Aug. 8-9 N = 12		Survey 44 Aug. 14-15 N = 12		Survey 45 Aug. 21-22 N = 12		Survey 46 Aug. 28-29 N = 12		Survey 47 Sept. 5-6 N = 12		Survey 48 Sept. 11-12 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1.8
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	1	1.8	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	2	3.2	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	413		130		279		1,023		124		141		165		426	
Crabs																	
Cancer antennarius (megalops)	brown rock crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer jordani (megalops)	hairy rock crab	-	-	5	7.4	-	-	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (megalops)	yellow rock crab	1	1.7	-	-	1	1.5	1	1.4	-	-	-	-	-	-	1	1.4
Cancer gracilis (megalops)	slender rock crab	-	-	-	-	-	-	1	1.4	1	1.8	-	-	-	-	-	-
Carcinus maenas (megalops)	European green crab	2	2.5	-	-	1	1.9	2	2.9	-	-	2	2.6	7	11.9	9	13.4
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	1	1.4	-	-	-	-	1	1.6	-	-
Cancer spp. (megalops)	cancer crabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	3		5		2		5		1		2		8		10	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 49 Sept. 17-18 N = 12		Survey 50 Sept. 25-26 N = 11		Survey 51 Oct. 3-4 N = 12		Survey 52 Oct. 9-10 N = 12		Survey 53 Oct. 16-17 Not Sampled		Survey 54 Oct. 25-26 N = 12		Survey 55 Oct. 30-31 N = 12		Survey 56 Nov. 6-7 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	47	78.1	437	733.0	96	155.2	721	1219.6			480	651.4	399	558.0	156	264.8
Hypsoblennius spp.	blennies	14	22.2	6	8.8	7	11.7	6	10.2			1	1.1	2	2.7	-	-
Leptocottus armatus	Pacific staghorn sculpin	1	1.6	-	-	1	1.4	3	5.1			11	14.9	38	53.0	25	40.2
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	2	3.1			-	-	-	-	-	-
Eucyclogobius newberryi	tidewater goby	-	-	5	11.1	-	-	2	3.2			-	-	-	-	-	-
Coryphopterus nicholsi	blackeye goby	25	37.8	8	10.1	5	7.1	2	3.5			5	6.6	4	6.2	1	1.9
Atherinopsis californiensis	jacksmelt	-	-	-	-	-	-	-	-			1	1.2	1	1.1	2	3.0
larval fish fragment	unidentified larval fishes	2	3.3	1	3.1	2	3.0	1	1.8			21	29.1	-	-	8	14.0
Sebastes spp. V_De	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Clupea pallasii	Pacific herring	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Gillichthys mirabilis	longjaw mudsucker	-	-	38	63.6	-	-	11	18.4			5	7.0	3	4.1	1	1.9
Genyonemus lineatus	white croaker	-	-	-	-	1	1.4	-	-			-	-	26	40.4	1	1.8
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Lepidogobius lepidus	bay goby	1	1.7	1	1.5	9	17.2	6	10.2			15	19.2	2	3.1	12	20.4
Atherinidae unid.	silversides	-	-	-	-	-	-	-	-			1	1.1	3	5.2	1	1.3
Engraulis mordax	northern anchovy	-	-	-	-	1	1.4	1	1.3			1	1.3	17	25.0	-	-
Scorpaenichthys marmoratus	cabezon	-	-	-	-	1	1.4	-	-			1	1.6	-	-	2	3.5
Sebastes spp. V	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Tarletonbeania crenularis	blue lanternfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	1	1.7	-	-	-	-			1	1.1	6	9.6	-	-
Bathymasteridae unid.	ronquils	-	-	-	-	-	-	-	-			-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	1	1.6	-	-	2	3.7	-	-			2	3.0	1	1.7	-	-
Cottidae unid.	sculpins	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	-	-	-	-	2	2.6	-	-			-	-	-	-	2	3.1
Stichaeidae unid.	pricklebacks	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Oligocottus spp.	sculpins	-	-	1	1.4	-	-	-	-			-	-	-	-	-	-
Cebidichthys violaceus	monkeyface eel	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Bathylagus ochotensis	popeye blacksmelt	-	-	-	-	-	-	-	-			-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	2	2.8	-	-			-	-	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	1	1.8			-	-	-	-	-	-
Liparis spp.	snailfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	1	1.7	2	3.2	1	1.8			1	1.6	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	1	1.7	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Blennioidei	blennies	-	-	-	-	-	-	-	-			-	-	-	-	1	1.6
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	1	1.7	-	-	-	-			-	-	-	-	-	-

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 49 Sept. 17-18 N = 12 Ct.	Conc.	Survey 50 Sept. 25-26 N = 11 Ct.	Conc.	Survey 51 Oct. 3-4 N = 12 Ct.	Conc.	Survey 52 Oct. 9-10 N = 12 Ct.	Conc.	Survey 53 Oct. 16-17 Not Sampled Ct.	Conc.	Survey 54 Oct. 25-26 N = 12 Ct.	Conc.	Survey 55 Oct. 30-31 N = 12 Ct.	Conc.	Survey 56 Nov. 6-7 N = 12 Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-			-	-	2	3.5	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	1	1.7			1	1.1	-	-	-	-
Agonidae unid.	poachers	-	-	-	-	-	-	-	-			-	-	1	1.1	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Seriphus politus	queenfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-			1	1.1	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	1	1.4	-	-			-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-			-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-			1	1.2	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-			-	-	-	-	-	-
	Total:	92		500		132		758		0		549		505		212	
Crabs																	
Cancer antennarius (megalops)	brown rock crab	-	-	-	-	-	-	-	-			-	-	1	1.1	-	-
Cancer jordani (megalops)	hairy rock crab	-	-	2	2.7	-	-	-	-			1	1.4	-	-	1	1.3
Cancer anthonyi (megalops)	yellow rock crab	-	-	-	-	1	1.8	-	-			-	-	3	4.1	-	-
Cancer gracilis (megalops)	slender rock crab	-	-	1	1.5	-	-	1	1.7			1	1.6	-	-	-	-
Carcinus maenas (megalops)	European green crab	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	-	-	-	-	-	-	-	-			-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	-	-	-	-	-	-	-	-			-	-	-	-	-	-
	Total:	0		3		1		1		0		2		4		1	

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at 4-hour Intervals over a 24-hour period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 57 Nov. 13-14 N = 12		Survey 58 Nov. 20-21 N = 12		Survey 59 Nov. 27-28 N = 12		Survey 60 Dec. 4-5 N = 12		Survey 61 Dec. 11-12 N = 12		Survey 62 Dec. 18-19 N = 12		Survey 63 Dec. 28-29 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Gobiidae unid.	gobies	144	200.8	431	619.7	263	367.8	255	378.4	378	436.1	277	389.6	148	212.1
Hypsoblennius spp.	blennies	-	-	1	1.1	-	-	-	-	2	2.4	-	-	-	-
Leptocottus armatus	Pacific staghorn sculpin	6	9.2	27	40.0	62	90.3	14	18.8	22	26.8	3	4.4	21	27.3
Stenobrachius leucopsarus	northern lampfish	-	-	2	2.6	-	-	2	2.7	1	1.3	5	6.1	5	5.8
Eucyclogobius newberryi	tidewater goby	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coryphopterus nicholsi	blackeye goby	1	1.3	1	1.5	7	9.3	-	-	-	-	-	-	1	1.6
Atherinopsis californiensis	jacksmelt	3	4.5	1	1.3	10	14.3	4	5.6	1	1.1	1	1.1	9	10.2
larval fish fragment	unidentified larval fishes	5	6.5	1	1.7	2	2.6	1	1.5	-	-	5	6.9	-	-
Sebastes spp. V_De	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupea pallasii	Pacific herring	-	-	3	4.2	3	4.4	8	12.3	191	218.5	-	-	6	8.5
Gillichthys mirabilis	longjaw mudsucker	12	16.7	-	-	6	8.6	2	2.9	10	11.3	-	-	-	-
Genyonemus lineatus	white croaker	4	6.0	3	3.6	2	2.6	1	1.5	14	19.3	-	-	12	13.6
Atherinops affinis	topsmelt	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidogobius lepidus	bay goby	1	1.4	3	5.0	4	7.0	31	49.0	24	30.9	10	12.9	-	-
Atherinidae unid.	silversides	4	6.0	-	-	-	-	-	-	-	-	4	5.0	-	-
Engraulis mordax	northern anchovy	-	-	7	10.8	4	4.9	-	-	6	7.5	-	-	1	1.5
Scorpaenichthys marmoratus	cabezon	12	20.7	6	9.4	2	3.8	2	3.0	14	17.5	5	6.6	1	1.1
Sebastes spp. V	rockfishes	-	-	3	5.0	-	-	-	-	-	-	-	-	3	4.2
Tarletonbeania crenularis	blue lanternfish	-	-	1	1.6	2	3.5	-	-	-	-	-	-	-	-
Gibbonsia spp.	clinid kelpfishes	-	-	1	1.5	3	5.9	-	-	3	3.8	-	-	-	-
Bathymasteridae unid.	ronquils	-	-	-	-	-	-	-	-	-	-	-	-	-	-
larval fish - damaged	unidentified larval fishes	-	-	-	-	6	8.6	-	-	-	-	-	-	-	-
Cottidae unid.	sculpins	1	1.8	-	-	-	-	-	-	-	-	1	1.2	1	1.4
Chaenopsidae unid.	tube blennies	3	4.4	-	-	2	3.3	-	-	-	-	-	-	-	-
Stichaeidae unid.	pricklebacks	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	-	-	-	-	-	-	-	-	1	1.1	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocottus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cebidichthys violaceus	monkeyface eel	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	-	-	1	1.6	1	0.9
Bathylagus ochotensis	popeye blacksmelt	-	-	-	-	-	-	-	-	-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	-	-	-	-	-	-	-	-	5	7.3
Liparis spp.	snailfishes	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathus spp.	pipefishes	-	-	1	1.5	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	5	8.2	-	-	1	1.5	-	-	2	2.9
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	-	-	-	-	-	-	1	1.3	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammodytes hexapterus	Pacific sand lance	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys sordidus	Pacific sanddab	-	-	4	6.4	-	-	1	1.5	2	2.6	-	-	1	1.5
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blennioidei	blennies	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	1	1.5	-	-	-	-
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	-	-	-	-	1	1.6

Table F-1 (continued). Weekly Survey Mean Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crab Collected at 4-hour Intervals over a 24-hour Period at the MBPP Intake Station: June 21 through August 10, 1999 and December 14, 1999 through December 29, 2000.

Taxon	Common Name	Survey 57 Nov. 13-14 N = 12		Survey 58 Nov. 20-21 N = 12		Survey 59 Nov. 27-28 N = 12		Survey 60 Dec. 4-5 N = 12		Survey 61 Dec. 11-12 N = 12		Survey 62 Dec. 18-19 N = 12		Survey 63 Dec. 28-29 N = 12	
		Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.	Ct.	Conc.
Citharichthys stigmaeus	speckled sanddab	-	-	-	-	-	-	1	1.5	-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	-	-	3	3.4	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	2	2.7	-	-	-	-	1	1.4	-	-	-	-	-	-
Agonidae unid.	poachers	1	1.4	-	-	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	1	1.5	-	-	1	1.2
Seriphus politus	queenfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis spp.	combfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannobrachium ritteri	broadfin lampfish	-	-	-	-	-	-	-	-	-	-	1	1.3	-	-
Oligocottus maculosus	tidepool sculpin	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes spp. V_D_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulorhynchus flavidus	tubesnout	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoclinus spp.	fringeheads	-	-	1	1.6	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	-	-	-	-	1	1.5	-	-	-	-
Sebastes spp. V_	rockfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentina sialis	Pacific argentine	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brosmophycis marginata	red brotula	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae unid.	clinid kelpfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Diogenichthys atlanticus	longfin lanternfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haemulidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypsopsetta spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Icelinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Merluccius productus	Pacific hake	-	-	-	-	-	-	-	-	-	-	-	-	1	1.2
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	1	1.3	-	-	-	-
Nannobrachium spp.	lanternfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruscarius spp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sebastes aurora	aurora rockfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternoptyx spp.	hatchetfishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipteridae	ribbon fishes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trachipterus altivelis	king-of-the-salmon	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaniolepis frenata	shortspine combfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total:	200		497		383		324		679		314		220	
Crabs															
Cancer antennarius (megalops)	brown rock crab	1	1.8	10	14.2	-	-	3	4.6	-	-	-	-	8	10.3
Cancer jordani (megalops)	hairy rock crab	1	1.3	5	7.1	-	-	-	-	-	-	1	1.5	-	-
Cancer anthonyi (megalops)	yellow rock crab	7	10.2	17	23.9	3	4.0	4	5.5	1	1.3	2	2.4	6	7.0
Cancer gracilis (megalops)	slender rock crab	-	-	1	1.4	-	-	-	-	-	-	1	1.5	-	-
Carcinus maenas (megalops)	European green crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer productus (megalops)	red rock crab	1	1.8	1	1.3	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	1	1.8	2	2.8	-	-	-	-	-	-	-	-	-	-
	Total:	11		36		3		7		1		4		14	

Table F-2. Monthly* Mean Survey Concentrations (#/1,000 m3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Total All Surveys	Survey 1 June 21, 1999 N = 16		Survey 2 July 19, 1999 N = 16		Survey 3 Dec. 14 & Dec. 20, 1999 N = 16		Survey 4 January 17, 2000 N = 16		Survey 5 February 28-29, 2000 N = 32	
			Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Gobiidae unid.	gobies	35,848	326	328.3	826	934.1	429	510.5	2,659	2632.7	4,556	2309.1
Eucyclogobius newberryi	tidewater goby	6,287	-	-	53	58.1	-	-	-	-	64	34.8
Leptocottus armatus	Pacific staghorn sculpin	638	-	-	-	-	49	57.8	77	72.0	23	11.3
larval fish fragment	unidentified larval fishes	458	1	0.6	4	4.4	9	11.5	7	7.4	75	42.6
Atherinopsis californiensis	jacksmelt	334	-	-	-	-	3	4.0	41	43.7	164	87.1
Atherinops affinis	topsmelt	267	3	3.0	6	6.9	-	-	-	-	1	0.5
Stenobrachius leucopsarus	northern lampfish	243	1	0.5	-	-	20	21.2	20	17.4	7	2.8
Engraulis mordax	northern anchovy	189	-	-	4	3.7	-	-	-	-	2	0.8
Hypsoblennius spp.	blennies	156	16	16.2	33	34.5	-	-	-	-	1	0.5
Clupea pallasii	Pacific herring	149	-	-	-	-	20	23.8	18	17.5	20	10.8
Sebastes spp. V_De	rockfishes	143	1	0.8	-	-	-	-	-	-	3	1.3
Coryphopterus nicholsi	blackeye goby	136	1	0.9	5	5.0	1	1.0	-	-	1	0.4
Lepidogobius lepidus	bay goby	112	-	-	-	-	-	-	2	1.6	4	1.7
Gillichthys mirabilis	longjaw mudsucker	98	1	1.0	3	3.3	2	2.5	8	7.9	-	-
larval fish - damaged	unidentified larval fishes	93	-	-	-	-	-	-	7	6.8	42	21.2
Genyonemus lineatus	white croaker	83	-	-	-	-	2	2.1	-	-	3	1.7
Scorpaenichthys marmoratus	cabezon	80	-	-	-	-	-	-	5	4.6	27	14.9
Bathymasteridae unid.	ronquils	64	1	0.9	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	60	-	-	1	1.1	-	-	1	1.1	1	0.5
Atherinidae unid.	silversides	57	1	1.0	2	2.5	-	-	16	16.6	2	1.2
Cottidae unid.	sculpins	55	2	1.6	2	1.8	-	-	1	0.8	8	4.4
Gibbonsia spp.	clinid kelpfishes	44	-	-	-	-	1	1.2	2	1.6	20	10.7
Tarletonbeania crenularis	blue lanternfish	43	-	-	-	-	-	-	2	1.7	1	0.4
Liparis spp.	snailfishes	42	1	0.8	-	-	-	-	1	0.8	-	-
Cebidichthys violaceus	monkeyface eel	34	-	-	1	0.9	-	-	-	-	2	0.9
Stichaeidae unid.	pricklebacks	31	-	-	-	-	3	3.5	-	-	3	1.5
Sebastes spp. V	rockfishes	30	-	-	-	-	1	0.9	1	0.8	-	-
Syngnathus spp.	pipefishes	29	-	-	-	-	1	1.3	-	-	1	0.7
Oligocottus spp.	sculpins	25	-	-	-	-	1	1.1	2	2.0	7	3.3
Syngnathus leptorhynchus	bay pipefish	25	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	24	-	-	-	-	-	-	-	-	4	2.0
larval/post-larval fish, unid.	unidentified larval fishes	22	1	0.9	-	-	-	-	-	-	-	-
Sebastes spp. V_D	rockfishes	21	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	19	-	-	-	-	-	-	-	-	-	-
Bathylagus ochotensis	popeye blacksmelt	18	-	-	-	-	-	-	2	1.7	-	-
Clinocottus analis	wooly sculpin	16	-	-	-	-	-	-	-	-	2	0.9
Citharichthys sordidus	Pacific sanddab	14	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	14	-	-	-	-	-	-	-	-	-	-
Typhlogobius californiensis	blind goby	14	2	1.6	-	-	-	-	-	-	-	-
Platichthys stellatus	starry flounder	13	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	12	-	-	-	-	6	7.0	-	-	-	-
Artedius spp.	sculpins	11	-	-	1	0.9	-	-	-	-	-	-
Pholididae unid.	gunnels	10	-	-	-	-	-	-	-	-	8	4.2
Parophrys vetulus	English sole	8	-	-	-	-	-	-	-	-	-	-

*Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Table F-2 (continued). Monthly* Mean Survey Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Total All Surveys	Survey 1 June 21, 1999 N = 16		Survey 2 July 19, 1999 N = 16		Survey 3 Dec. 14 & Dec. 20, 1999 N = 16		Survey 4 January 17, 2000 N = 16		Survey 5 February 28-29, 2000 N = 32	
			Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Ruscarius creaseri	rouchcheek sculpin	8	-	-	-	-	-	-	-	-	2	1.1
Hexagrammidae unid.	greenlings	6	-	-	-	-	-	-	2	2.1	2	1.1
Pleuronectiformes unid.	flatfishes	6	-	-	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	6	-	-	1	1.1	-	-	-	-	-	-
Citharichthys stigmaeus	speckled sanddab	5	-	-	-	-	-	-	-	-	-	-
Oxylebius pictus	painted greenling	5	1	0.8	-	-	-	-	-	-	2	1.1
Pleuronichthys verticalis	honeyhead turbot	5	-	-	-	-	-	-	-	-	-	-
Pleuronectes bilineatus	rock sole	4	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	3	-	-	-	-	-	-	-	-	1	0.4
Paralichthys californicus	California halibut	3	-	-	-	-	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	3	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croaker	3	-	-	-	-	-	-	-	-	-	-
Agonidae unid.	poachers	2	-	-	-	-	-	-	1	0.9	-	-
Clupeidae unid.	herrings	2	-	-	-	-	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	2	-	-	-	-	1	1.2	-	-	-	-
Cottus asper	prickly sculpin	2	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	2	-	-	-	-	-	-	-	-	-	-
Liparis fucensis	slipskin snailfish	2	-	-	-	-	-	-	-	-	-	-
Microstomus pacificus	Dover sole	2	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	2	-	-	-	-	-	-	-	-	-	-
Osmeridae unid.	smelts	2	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	2	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	1	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	1	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	1	-	-	-	-	-	-	1	0.8	-	-
Myctophidae unid.	lanternfishes	1	-	-	-	-	-	-	-	-	-	-
Nannobrachium regalis	pinpoint lanternfish	1	-	-	-	-	-	-	1	0.9	-	-
Odontopyxis trispinosa	pygmy poacher	1	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	1	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	1	-	-	-	-	-	-	-	-	-	-
Radulinus spp.	sculpins	1	-	-	-	-	-	-	-	-	-	-
Sebastolobus spp.	thornyheads	1	-	-	-	-	-	-	-	-	-	-
Xenistius califoriensis		1	-	-	-	-	-	-	-	-	-	-
	Total	46,157	359		942		549		2,877		5,059	
Crabs												
Cancer antennarius (megalops)	brown rock crab	9,507	-	-	-	-	-	-	-	-	1	0.6
Cancer jordani (megalops)	hairy rock crab	326	-	-	-	-	1	0.9	-	-	-	-
Carcinus maenas (megalops)	European green crab	87	-	-	-	-	-	-	-	-	-	-
Cancer gracilis (megalops)	slender rock crab	80	-	-	-	-	-	-	-	-	-	-
Cancer anthonyi (megalops)	yellow rock crab	66	-	-	-	-	1	1.2	-	-	-	-
Cancer productus (megalops)	red rock crab	32	-	-	-	-	-	-	-	-	-	-
Cancer spp. (megalops)	cancer crabs	12	-	-	-	-	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	2	-	-	-	-	-	-	-	-	-	-
	Total	10,112	0		0		2		0		1	

* Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Table F-2 (continued). Monthly* Mean Survey Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Survey 6 March 27-28 & April 3-4, 2000 N = 44		Survey 7 April 24-25 & May 3-4, 2000 N = 44		Survey 8 May 15-16 & May 22-23, 2000 N = 44		Survey 9 June 12-15, 2000 N = 47		Survey 10 July 10-12, 2000 N = 48	
		Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Gobiidae unid.	gobies	2,455	900.2	4,575	1723.1	3,384	1362.8	2,912	1130.8	2,378	834.7
Eucyclogobius newberryi	tidewater goby	63	22.4	519	197.6	578	228.5	246	98.9	1,297	447.7
Leptocottus armatus	Pacific staghorn sculpin	117	43.5	100	37.4	10	4.0	4	1.6	-	-
larval fish fragment	unidentified larval fishes	48	17.9	42	15.8	153	60.7	16	6.6	21	7.2
Atherinopsis californiensis	jacksmelt	27	10.3	4	1.6	-	-	-	-	-	-
Atherinops affinis	topsmelt	33	11.9	30	11.4	106	41.2	45	17.7	38	12.9
Stenobrachius leucopsarus	northern lampfish	123	47.3	48	16.6	12	4.6	2	0.9	-	-
Engraulis mordax	northern anchovy	50	20.0	11	4.5	7	2.6	12	4.6	45	15.1
Hypsoblennius spp.	blennies	1	0.4	1	0.3	2	0.8	7	2.9	24	8.6
Clupea pallasii	Pacific herring	1	0.2	-	-	-	-	-	-	-	-
Sebastes spp. V_De	rockfishes	14	5.5	107	39.2	15	5.3	3	1.3	-	-
Coryphopterus nicholsi	blackeye goby	1	0.4	8	3.0	49	19.9	4	2.0	7	2.4
Lepidogobius lepidus	bay goby	1	0.4	-	-	-	-	7	2.7	10	3.9
Gillichthys mirabilis	longjaw mudsucker	2	0.8	10	3.7	13	4.9	18	6.9	-	-
larval fish - damaged	unidentified larval fishes	1	0.2	2	0.7	29	11.9	2	0.9	6	2.0
Genyonemus lineatus	white croaker	30	10.6	8	3.1	-	-	-	-	-	-
Scorpaenichthys marmoratus	cabezon	3	0.9	-	-	1	0.3	-	-	-	-
Bathymasteridae unid.	ronquils	32	11.9	4	1.5	13	4.7	9	4.4	4	1.6
Chaenopsidae unid.	tube blennies	1	0.1	1	0.3	2	0.8	14	5.9	9	3.2
Atherinidae unid.	silversides	9	3.4	3	1.0	11	4.9	3	1.2	3	1.0
Cottidae unid.	sculpins	6	2.2	3	1.3	13	5.3	5	1.9	2	0.7
Gibbonsia spp.	clinid kelpfishes	1	0.4	1	0.4	12	4.0	-	-	1	0.4
Tarletonbeania crenularis	blue lanternfish	25	9.4	2	0.6	3	1.1	-	-	-	-
Liparis spp.	snailfishes	5	1.9	2	0.7	16	5.9	15	9.3	-	-
Cebidichthys violaceus	monkeyface eel	-	-	5	1.8	23	7.9	3	1.0	-	-
Stichaeidae unid.	pricklebacks	4	1.6	3	1.0	5	1.8	10	3.2	2	0.7
Sebastes spp. V	rockfishes	2	0.8	2	0.6	5	1.7	14	5.4	1	0.5
Syngnathus spp.	pipefishes	-	-	-	-	1	0.5	2	0.7	8	2.7
Oligocottus spp.	sculpins	1	0.4	1	0.3	13	4.8	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	-	-	-	-	-	-	-	-	-	-
Artedius lateralis	smoothhead sculpin	4	1.5	2	0.7	9	3.5	3	1.2	1	0.3
larval/post-larval fish, unid.	unidentified larval fishes	2	0.7	-	-	5	2.2	1	0.4	-	-
Sebastes spp. V_D	rockfishes	-	-	14	6.9	5	1.8	2	0.6	-	-
Pleuronectidae unid.	flounders	11	4.2	5	1.9	1	0.4	1	0.4	1	0.5
Bathylagus ochotensis	popeye blacksmelt	10	4.1	2	0.7	4	1.5	-	-	-	-
Clinocottus analis	wooly sculpin	1	0.4	-	-	7	2.4	1	0.4	3	1.2
Citharichthys sordidus	Pacific sanddab	-	-	-	-	-	-	-	-	-	-
Sebastes spp.	rockfishes	3	1.1	4	1.2	2	0.7	3	2.2	-	-
Typhlogobius californiensis	blind goby	1	0.4	1	0.3	-	-	-	-	-	-
Platichthys stellatus	starry flounder	10	3.5	3	1.0	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	4	1.6	-	-	-	-	1	0.4	-	-
Artedius spp.	sculpins	3	1.0	-	-	2	0.8	4	1.4	-	-
Pholididae unid.	gunnels	-	-	-	-	2	0.7	-	-	-	-
Parophrys vetulus	English sole	6	2.4	1	0.4	-	-	1	0.5	-	-

* Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Table F-2 (continued). Monthly* Mean Survey Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Survey 6 March 27-28 & April 3-4, 2000 N = 44 Count	Conc.	Survey 7 April 24-25 & May 3-4, 2000 N = 44 Count	Conc.	Survey 8 May 15-16 & May 22-23, 2000 N = 44 Count	Conc.	Survey 9 June 12-15, 2000 N = 47 Count	Conc.	Survey 10 July 10-12, 2000 N = 48 Count	Conc.
Ruscarius creaseri	rouchcheek sculpin	-	-	1	0.3	2	0.6	2	0.8	1	0.4
Hexagrammidae unid.	greenlings	-	-	1	0.3	-	-	1	0.5	-	-
Pleuronectiformes unid.	flatfishes	1	0.4	-	-	-	-	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	1	0.4
Citharichthys stigmaeus	speckled sanddab	1	0.4	1	0.5	-	-	-	-	-	-
Oxylebius pictus	painted greenling	-	-	-	-	1	0.4	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	-	-	-	-	3	1.1
Pleuronectes bilineatus	rock sole	-	-	4	1.7	-	-	-	-	-	-
Gobiesox spp.	clingfishes	1	0.4	1	0.4	-	-	-	-	-	-
Paralichthys californicus	California halibut	1	0.4	1	0.4	-	-	-	-	-	-
Psettichthys melanostictus	sand sole	3	1.2	-	-	-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	-	-	-	-	1	0.4	1	0.4
Agonidae unid.	poachers	-	-	-	-	-	-	-	-	-	-
Clupeidae unid.	herrings	-	-	1	0.3	-	-	-	-	-	-
Clupeiformes	herrings and anchovies	1	0.4	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	1	0.4	1	0.4	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	2	0.8	-	-	-	-	-	-
Liparis fucensis	slipskin snailfish	-	-	-	-	-	-	-	-	-	-
Microstomus pacificus	Dover sole	2	0.8	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	-	-	-	-
Osmeridae unid.	smelts	1	0.6	1	0.3	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	1	0.4	-	-	1	0.3	-	-	-	-
Citharichthys spp.	sanddabs	-	-	1	0.4	-	-	-	-	-	-
Diaphus theta	California headlight fish	1	0.4	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	-	-	-	-	-	-	-	-	-	-
Nannobrachium regalis	pinpoint lanternfish	-	-	-	-	-	-	-	-	-	-
Odontopyxis trispinosa	pygmy poacher	-	-	-	-	-	-	-	-	-	-
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	1	0.4
Pleuronichthys spp.	turbots	-	-	-	-	-	-	-	-	-	-
Radulinus spp.	sculpins	-	-	-	-	-	-	-	-	1	0.3
Sebastolobus spp.	thornyheads	1	0.4	-	-	-	-	-	-	-	-
Xenistius califoriensis		-	-	-	-	-	-	-	-	-	-
	Total	3,126		5,539		4,517		3,374		3,869	
Crabs											
Cancer antennarius (megalops)	brown rock crab	6	2.3	7,803	3263.6	1,513	575.3	121	46.6	8	2.9
Cancer jordani (megalops)	hairy rock crab	12	4.7	32	13.2	163	59.5	13	5.3	17	6.1
Carcinus maenas (megalops)	European green crab	-	-	3	1.3	16	6.4	6	3.2	17	6.2
Cancer gracilis (megalops)	slender rock crab	4	1.6	1	0.5	14	5.3	-	-	-	-
Cancer anthonyi (megalops)	yellow rock crab	-	-	2	0.8	9	3.2	4	1.6	3	1.1
Cancer productus (megalops)	red rock crab	3	1.2	2	0.8	15	5.6	1	0.5	-	-
Cancer spp. (megalops)	cancer crabs	-	-	11	4.0	-	-	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	2	0.8	-	-	-	-
	Total	25		7,854		1,732		145		45	

* Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Table F-2 (continued). Monthly* Mean Survey Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Survey 11 August 7-9, 2000 N = 48		Survey 12 September 5-7, 2000 N = 48		Survey 13 October 2-4, 2000 N = 48		Survey 14 Nov. 27-28 & Dec. 4-5, 2000 N = 48		Survey 15 December 18-19, 2000 N = 48	
		Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Gobiidae unid.	gobies	2,696	1047.6	3,231	1367.9	816	330.8	2,616	908.1	1,989	681.5
Eucyclogobius newberryi	tidewater goby	2,041	813.7	1,347	607.0	71	30.0	7	2.5	1	0.3
Leptocottus armatus	Pacific staghorn sculpin	1	0.4	2	0.7	5	1.9	232	87.0	18	5.9
larval fish fragment	unidentified larval fishes	29	11.3	23	9.6	-	-	17	6.3	13	4.5
Atherinopsis californiensis	jacksmelt	1	0.4	3	1.4	2	0.9	39	15.0	50	16.5
Atherinops affinis	topsmelt	5	1.8	-	-	-	-	-	-	-	-
Stenobrachius leucopsarus	northern lampfish	-	-	-	-	-	-	1	0.3	9	2.9
Engraulis mordax	northern anchovy	-	-	3	1.2	12	4.0	33	10.1	10	2.9
Hypsoblennius spp.	blennies	29	11.6	27	9.9	15	5.7	-	-	-	-
Clupea pallasii	Pacific herring	-	-	-	-	-	-	61	22.1	29	9.6
Sebastes spp. V_De	rockfishes	-	-	-	-	-	-	-	-	-	-
Coryphopterus nicholsi	blackeye goby	8	3.2	18	6.9	25	9.5	8	2.9	-	-
Lepidogobius lepidus	bay goby	16	6.6	24	9.2	24	9.5	24	9.1	-	-
Gillichthys mirabilis	longjaw mudsucker	1	0.4	3	1.4	2	0.8	35	12.9	-	-
larval fish - damaged	unidentified larval fishes	-	-	1	0.3	-	-	1	0.4	2	0.8
Genyonemus lineatus	white croaker	7	3.0	2	0.9	13	4.6	15	5.3	3	0.8
Scorpaenichthys marmoratus	cabezon	-	-	-	-	4	1.7	26	9.4	14	4.2
Bathymasteridae unid.	ronquils	1	0.4	-	-	-	-	-	-	-	-
Chaenopsidae unid.	tube blennies	18	7.5	7	2.7	3	1.1	2	0.5	-	-
Atherinidae unid.	silversides	-	-	-	-	1	0.4	2	0.8	4	1.3
Cottidae unid.	sculpins	8	3.1	1	0.4	1	0.3	2	0.7	1	0.3
Gibbonsia spp.	clinid kelpfishes	-	-	1	0.4	-	-	1	0.4	4	1.4
Tarletonbeania crenularis	blue lanternfish	1	0.3	-	-	4	1.2	5	1.7	-	-
Liparis spp.	snailfishes	-	-	-	-	2	0.8	-	-	-	-
Cebidichthys violaceus	monkeyface eel	-	-	-	-	-	-	-	-	-	-
Stichaeidae unid.	pricklebacks	1	0.4	-	-	-	-	-	-	-	-
Sebastes spp. V	rockfishes	-	-	-	-	1	0.3	3	1.1	-	-
Syngnathus spp.	pipefishes	-	-	11	4.4	2	0.9	3	1.0	-	-
Oligocottus spp.	sculpins	-	-	-	-	-	-	-	-	-	-
Syngnathus leptorhynchus	bay pipefish	12	4.4	1	0.5	6	2.1	6	2.0	-	-
Artedius lateralis	smoothhead sculpin	1	0.4	-	-	-	-	-	-	-	-
larval/post-larval fish, unid.	unidentified larval fishes	1	0.5	-	-	11	4.3	-	-	1	0.4
Sebastes spp. V_D	rockfishes	-	-	-	-	-	-	-	-	-	-
Pleuronectidae unid.	flounders	-	-	-	-	-	-	-	-	-	-
Bathylagus ochotensis	popeye blacksmelt	-	-	-	-	-	-	-	-	-	-
Clinocottus analis	wooly sculpin	-	-	1	0.4	-	-	1	0.4	-	-
Citharichthys sordidus	Pacific sanddab	-	-	1	0.3	7	2.2	5	1.6	1	0.3
Sebastes spp.	rockfishes	-	-	-	-	-	-	2	0.6	-	-
Typhlogobius californiensis	blind goby	-	-	-	-	-	-	-	-	10	3.7
Platichthys stellatus	starry flounder	-	-	-	-	-	-	-	-	-	-
Sebastes spp. VD	rockfishes	-	-	-	-	-	-	1	0.3	-	-
Artedius spp.	sculpins	-	-	-	-	-	-	-	-	1	0.4
Pholididae unid.	gunnels	-	-	-	-	-	-	-	-	-	-
Parophrys vetulus	English sole	-	-	-	-	-	-	-	-	-	-

* Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Table F-2 (continued). Monthly* Mean Survey Concentrations (#/1,000 m^3) of Larval Fishes and Megalopal Cancrid Crabs Collected at MBPP Source Water Stations: June and July 1999 and December 1999 through December 2000.

Taxon	Common Name	Survey 11 August 7-9, 2000 N = 48		Survey 12 September 5-7, 2000 N = 48		Survey 13 October 2-4, 2000 N = 48		Survey 14 Nov. 27-28 & Dec. 4-5, 2000 N = 48		Survey 15 December 18-19, 2000 N = 48	
		Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.	Count	Conc.
Ruscarius creaseri	rouchcheek sculpin	-	-	-	-	-	-	-	-	-	-
Hexagrammidae unid.	greenlings	-	-	-	-	-	-	-	-	-	-
Pleuronectiformes unid.	flatfishes	-	-	-	-	5	1.7	-	-	-	-
Syngnathidae unid.	pipefishes	-	-	-	-	-	-	-	-	4	1.5
Citharichthys stigmaeus	speckled sanddab	1	0.4	-	-	2	0.6	-	-	-	-
Oxylebius pictus	painted greenling	-	-	1	0.4	-	-	-	-	-	-
Pleuronichthys verticalis	honeyhead turbot	-	-	-	-	2	0.6	-	-	-	-
Pleuronectes bilineatus	rock sole	-	-	-	-	-	-	-	-	-	-
Gobiesox spp.	clingfishes	-	-	-	-	-	-	-	-	-	-
Paralichthys californicus	California halibut	-	-	-	-	1	0.4	-	-	-	-
Psettichthys melanostictus	sand sole	-	-	-	-	-	-	-	-	-	-
Sciaenidae unid.	croaker	-	-	1	0.4	-	-	-	-	-	-
Agonidae unid.	poachers	-	-	1	0.4	-	-	-	-	-	-
Clupeidae unid.	herrings	-	-	-	-	-	-	-	-	1	0.2
Clupeiformes	herrings and anchovies	-	-	-	-	-	-	-	-	-	-
Cottus asper	prickly sculpin	-	-	-	-	-	-	-	-	-	-
Labrisomidae unid.	labrisomid kelpfishes	-	-	-	-	-	-	-	-	-	-
Liparis fucensis	slipskin snailfish	-	-	2	0.8	-	-	-	-	-	-
Microstomus pacificus	Dover sole	-	-	-	-	-	-	-	-	-	-
Orthonopias triacis	snubnose sculpin	-	-	-	-	-	-	1	0.4	1	0.4
Osmeridae unid.	smelts	-	-	-	-	-	-	-	-	-	-
Sardinops sagax	Pacific sardine	-	-	-	-	-	-	-	-	-	-
Citharichthys spp.	sanddabs	-	-	-	-	-	-	-	-	-	-
Diaphus theta	California headlight fish	-	-	-	-	-	-	-	-	-	-
Icichthys lockingtoni	medusa fish	-	-	-	-	-	-	-	-	-	-
Myctophidae unid.	lanternfishes	1	0.4	-	-	-	-	-	-	-	-
Nannobrachium regalis	pinpoint lanternfish	-	-	-	-	-	-	-	-	-	-
Odontopyxis trispinosa	pygmy poacher	-	-	-	-	-	-	-	-	1	0.4
Paralichthyidae unid.	lefteye flounders & sanddabs	-	-	-	-	-	-	-	-	-	-
Pleuronichthys spp.	turbots	-	-	-	-	1	0.3	-	-	-	-
Radulinus spp.	sculpins	-	-	-	-	-	-	-	-	-	-
Sebastolobus spp.	thornyheads	-	-	-	-	-	-	-	-	-	-
Xenistius californiensis		-	-	-	-	1	0.3	-	-	-	-
	Total	4,879		4,712		1,039		3,149		2,167	
Crabs											
Cancer antennarius (megalops)	brown rock crab	8	3.1	4	1.3	4	1.2	21	6.2	18	4.8
Cancer jordani (megalops)	hairy rock crab	14	5.6	20	6.7	7	2.6	2	0.6	45	12.1
Carcinus maenas (megalops)	European green crab	14	5.8	23	8.1	6	2.1	-	-	2	0.5
Cancer gracilis (megalops)	slender rock crab	13	5.5	11	3.7	10	3.6	6	1.8	21	6.0
Cancer anthonyi (megalops)	yellow rock crab	16	6.4	1	0.4	2	0.8	14	4.2	14	3.8
Cancer *productus* (megalops)	red rock crab	1	0.4	4	1.4	-	-	3	0.8	3	0.8
Cancer spp. (megalops)	cancer crabs	-	-	-	-	1	0.3	-	-	-	-
Cancer magister (megalops)	dungeness crab	-	-	-	-	-	-	-	-	-	-
	Total	66		63		30		46		103	

* Samples were collected during daytime high and low tides in June, July, and December 1999 and January 2000. In February 2000 sampling was increased to 4-hour intervals over a continuous 24-hour period.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix G

Dr. Jacobs' Analysis of Mitochondrial Sequence Generated from Larval Gobies Provided by Tenera

and

Response by Dr. Giacomo Bernardi

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix G-1

Analysis of Mitochondrial Sequence Generated from Larval Gobies Provided to the Jacobs Lab by Tenera

by

David Jacobs, Ph.D
University of California at Los Angeles
January, 2001

ANALYSIS OF MITOCHONDRIAL SEQUENCE GENERATED FROM LARVAL GOBIES PROVIDED TO THE JACOBS LAB BY TENERA

DAVID JACOBS, PH.D

University of California at Los Angeles

January, 2001

Summary

Tenera provided 53 unknown larval fish recovered in Morro Bay to assess whether or not these larval fish were tidewater gobies. Sequencing of the mitochondrial control region documents that none of the 52 fish for which sequence was recovered are tidewater goby; one fish was unable to be sequenced.

The fish were received from Tenera in two sets of samples. An approximately 890 base pair mitochondrial control region sequence was recovered via PCR. Sufficient sequence was generated to construct a 594 base pair matrix. PCR and sequencing was successful for 52 of the 53 fish; only one fish (#19) from the second sample set remains unsequenced. Fourteen known goby sequences from six species were included in the analysis. These data were examined by comparing distances between all pairs of sequences, and by generating a parsimony-based phylogenetic tree. The analysis demonstrates that of the first sample set of 15 fish, the majority of the larval fish, 13, are shadow goby *Quietula y-cauda.* Two others are similar to each other, but they are quite distinct from the sequences we have in hand. They are likely to be a more open marine goby that we have yet to sample as they fall outside all the estuarine gobies included in the analysis. In the second set of 38 larval fish, 32 fish are shadow goby *Quietula y-cauda.* An additional five are *Clevelandia ios* the arrow goby.

Thus, of the 52 sequences generated 45 are shadow goby *Quietula y-cauda*, five are *Clevelandia ios* the arrow goby, and two remain unknown. All sequences generated are unequivocally different from *Eucyclogobius newberryi*, the tidewater goby.

General Methods Employed

DNA was extracted by digesting each larva in 6µl proteinase K (20mg/ml), 600µl CTAB (0.1M Tris (pH 8.0), 0.02M EDTA (pH 8.0), 0.02%(w/v) CTAB, 0.8M NaCl, 0.002% ß-mercaptoethanol), and 50µl 5M NaCl for 5 hours at 55^{o}C. At room temperature, digested samples were centrifuged for 5 minutes at 13,000 g before DNA was removed from the supernatants by a single extraction with chloroform:isoamyl-alcohol (24:1) followed by repeated extractions with phenol:chloroform:isoamyl-alcohol (25:24:1) until the interface between aqueous and organic phases was clear. A single chloroform:isoamyl-alcohol extraction was then completed before precipitating the DNA at -20°C for one hour with ~45µl 3M sodium acetate and ~1.2ml 100% ethanol. The precipitated DNA was centrifuged for 30 minutes at 13,000 g, washed in 75% ethanol, dried at 37°C, and dissolved in 50µl 10mM Tris-HCl (pH8.3).

Between 0.5µl and 1.0µl of this DNA solution was used in 50µl PCRs, set up according to the guidelines issued with *Taq* Polymerase (Perkin Elmer). PCRs, using MJ Research MiniCyclers, began with a 5 minute denaturation step, followed by 32 cycles, each cycle consisting of 45 seconds at 94°C, 45 sec. at 49-51°C, and 60-90 sec. at 72°C, depending on both the template and primers; PCRs terminated with a 10 minute extension step (72°C) then refrigeration (4°C). The mitochondrial control region was amplified using primers CR-A and CR-M (Lee *et al*. 1995). Cloned PCR products, generated via Invitrogen's TOPO TA cloning kit and Pharmacia's Flexiprep kit, were cycle sequenced on Applied Biosystems 373 Autosequencers according to protocols in the ABI PRISM manual using Invitrogen's M13 primers.

Approach

Although the larval gobies were small, a recent Ph.D in my lab, Mike Dawson, was able to recover sequence data from 52 of the 53 specimens provided. Mike has worked extensively with the population genetics of tidewater gobies and other marine taxa and is quite experienced at recovering mitochondrial sequence. He was able to extract DNA using standard methods, and PCR amplify the mitochondrial control region, a highly variable region that has been widely used in studies of divergence within and between species of vertebrates. These PCR products were then cloned, and the 5' end of the control sequence was then sequenced at a DNA sequencing facility at Cal-State Northridge and at Laragen (see methods section for details of standard application of these methods). This yielded @ 590 bases of alignable sequence. Sequences were aligned using a standard alignment program (Clustal W) with a range of sequences that Mike has assembled ancillary to his work on *Eucyclogobius.* The final data set included 14 known and 52 unknown sequences yielding a matrix of 66 sequences and 594 characters. This includes a number other Californian estuarine gobies (long-jawed mudsucker- *Gillichthys*, arrow goby – *Clevelandia*, shadow goby – *Quietula*, cheekspot goby- *Ilypnus*) as well as a member of the genus *Coryphopterus* from the Caribbean. Collection locality information is provided below.

Collection Locality Information for Known Samples

Species	Site	Collected by	Date	Method	Preservation
Coryphopterus glaucotroenum [Go22]	Caribbean	Mark Steele	Jan 1999	SCUBA	70% EtOH
Eucyclogobius newberryi _En164_SD	San Onofre, SD	Dan Holland	1990	Seine	Deep-frozen
Eucyclogobius newberryi _En519_SB	Refugio,SB	Dan Holland	1990	Seine	Deep-frozen
Gillichthys mirabilis #24	Ballona Tidal Gate, LA	Lauritzen & Fredericks	7/11/99	Seine	70% ethanol
Quietula y-cauda #s 1-3	Santa Margarita, SD	Holland & Swift	January 1999	Seine	Deep-frozen
1 *Quietula y-cauda* [_CiA_StaM_SD1]	Santa Margarita, SD	Camm Swift	1998/9	Seine	Deep-frozen
43 *Clevelandia ios*	San Luis Cr, SLO	Kristina Louie	1997-2000	Seine	Deep-frozen
12 *Clevelandia ios*	Anaheim Bay, LA	Kristina Louie	1997-2000	Seine	Deep-frozen
2 *Clevelandia ios*	Bodega Harbor, SO	Kristina Louie	1997-2000	Seine	Deep-frozen
1 *Ilypnus gilberti* [Cheekspot]	Carpinteria Marsh, SB.	Todd Huspeni	1999	Slurp-gun?	Deep-frozen
2 *Ilypnus gilberti* [Cheekspot]	Anaheim Bay, LA	Lauritzen & Fredericks	7/11/99	Seine	70% ethanol
Ilypnus gilberti #s3-4 [Cheekspot]	Long Beach, LA	Lauritzen & Fredericks	7/11/99	Seine	70% ethanol
Lepidogobius lepidis #s 1-3	Campbell C, Bodega Bay, SO	Don Buth	10/2/2000	Seine	95%
Lythripnus dalli #s 1-2	San Clemente Island	Dan Pondela	8/9/2000	SCUBA	95% EtOH
Lythripnus zebra #s 1-2	San Clemente Island	Dan Pondela	8/9/2000	SCUBA	95% EtOH
Coryphopterus nicholsii 1-3	King Harbor, Redondo B.	Dan Pondela	9/14/2000	SCUBA	(95% EtOH?)

Analysis of this data is presented in two ways, as a distance matrix appended below and as a tree reconstructed using parsimony. In the distance matrix comparisons between individuals within a species range in number of DNA changes from 0 to 25. Samples from our extensive data on tidewater goby, chosen to encompass the entire range of variation, differ at 25 positions reflecting distinct northern and southern forms of the tidewater goby. In these data the smallest difference between known species is in the range of 75-79 base changes between tidewater and arrow gobies. We, and others, have argued that these taxa are closely related. Thus based on the known sequences, the maximum within species variation is 25 bases or 4.2% and the minimum between species variation is 75 bases or 12.8%.

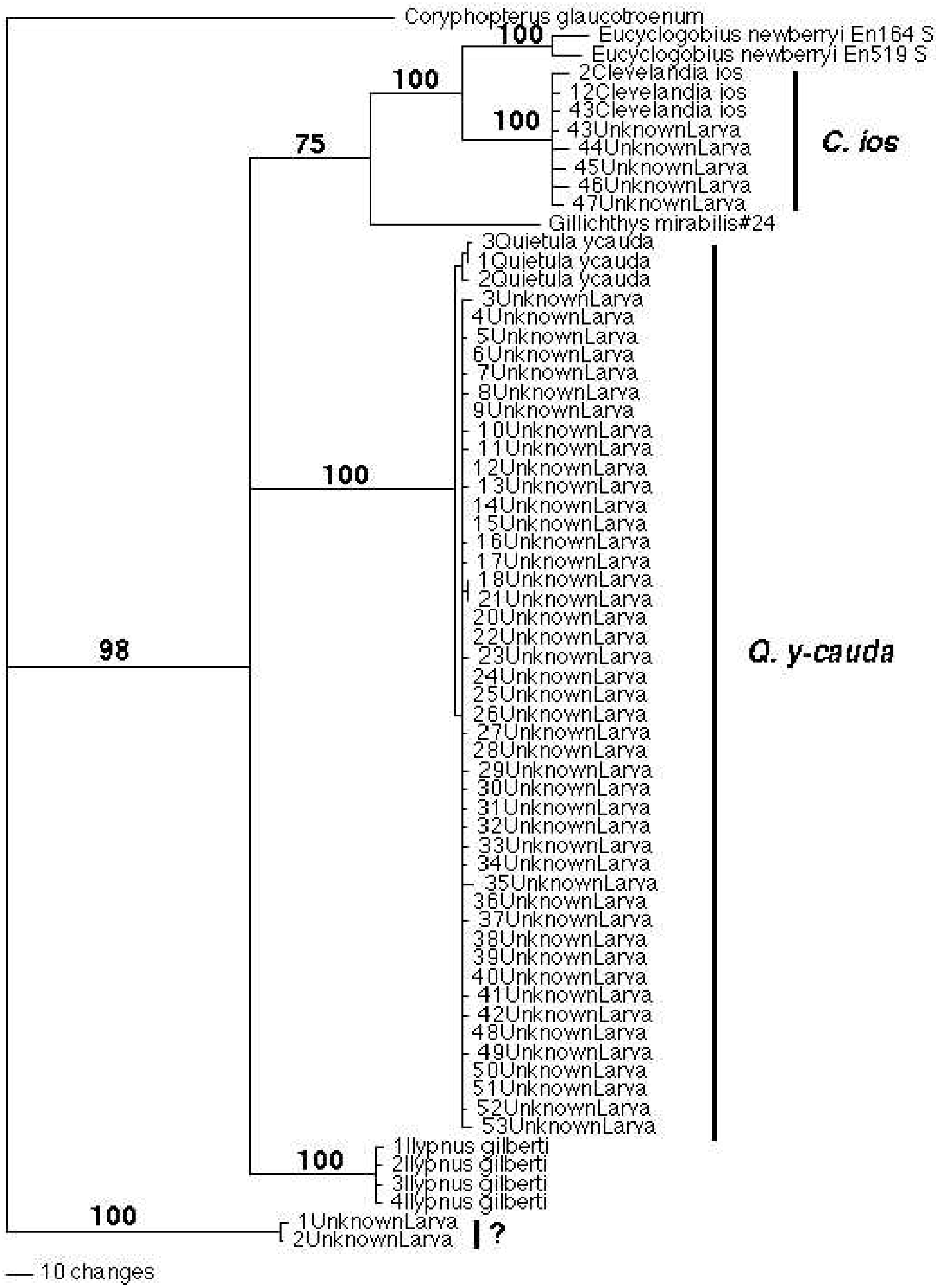
Unknown larvae 1 & 2 are closely related to each other (4 bases) but are unrelated to all the other gobies in the analysis. On the basis of these sequences it appears that these larvae may not be members of the estuarine group of gobies, a speculation consistent with their collection at high tide.

An additional 32 of the larval sequences (#'s 3-18, 20-42, 48-53) are also most closely related to each other differing by a range of 0-6 base changes. However, these sequences are only a few more bases different (7-11) from the three shadow goby (*Quietula*) sequences we have in the analysis. The known shadow goby sequences in the analysis are from fish caught in the Santa Margarita River in San Diego County. We interpret this slight difference as intra-specific geographic variation between Morro Bay and San Diego. We would point out that this difference is less than half that found *within* the tidewater goby across the same region.

The remaining five larvae (#'s 43-47) are inferred to be *Clevelandia.* They are differentiated from each other and from the known *Clevelandia* by a range of 4-11 base differences.

It is reassuring that there is some difference in these sequences from sequences previously generated in the lab as it allows for no possibility of laboratory contamination as the source of any of the sequences generated.

The interpretation is perhaps most easily visualized in the parsimony tree reconstruction generated using the program Paup 4*. This tree (see next page) was constructed using the parsimony/bootstrapping resampling technique implemented in Paup. Only those topologies present in more than 50% of the Bootstrap iterations are retained. Note that all the species level taxa are supported by 100% bootstrap values and that the sequence divergence within species is far less than between species (shown by branch length). As discussed above *Quietula* and the unknown samples that are inferred to be Q*uietula* show some within species structure that we attribute to geographic differentiation. However also note that the sequence divergence within "*Q. y-cauda"* inclusive of associated unknowns, as well as "*C. ios" inclusive* of associated unknowns is substantially less than between known *Eucyclogobius* sequences.



Coryphopterus glaucotroenum
100
Eucyclogobius newberryi En164 S
Eucyclogobius newberryi En519 S
100
2Clevelandia ios
12Clevelandia ios
43Clevelandia ios
100
43UnknownLarva
44UnknownLarva
45UnknownLarva
46UnknownLarva
47UnknownLarva
C. ios
75
Gillichthys mirabilis#24
3Quietula ycauda
1Quietula ycauda
2Quietula ycauda
3UnknownLarva
4UnknownLarva
5UnknownLarva
6UnknownLarva
7UnknownLarva
8UnknownLarva
9UnknownLarva
10UnknownLarva
11UnknownLarva
12UnknownLarva
13UnknownLarva
14UnknownLarva
15UnknownLarva
16UnknownLarva
17UnknownLarva
18UnknownLarva
21UnknownLarva
20UnknownLarva
22UnknownLarva
23UnknownLarva
24UnknownLarva
25UnknownLarva
26UnknownLarva
27UnknownLarva
28UnknownLarva
29UnknownLarva
30UnknownLarva
31UnknownLarva
32UnknownLarva
33UnknownLarva
34UnknownLarva
35UnknownLarva
36UnknownLarva
37UnknownLarva
38UnknownLarva
39UnknownLarva
40UnknownLarva
41UnknownLarva
42UnknownLarva
48UnknownLarva
49UnknownLarva
50UnknownLarva
51UnknownLarva
52UnknownLarva
53UnknownLarva
100
Q. y-cauda
98
100
1Ilypnus gilberti
2Ilypnus gilberti
3Ilypnus gilberti
4Ilypnus gilberti
100
1UnknownLarva
2UnknownLarva
?
10 changes

Relationship between sample information provided by Tenera and our sample numbers.

First Shipment

Survey/Sample#/#of fish	Collection Date	Fish# this analysis
S0002/8/2	6/28/99	1,2
S0002/9/1	6/29/99	3
S0002/11/2	6/29/99	4,5
S0005/3/5	7/19/99	6,7,8,9,10
S0005/4/5	7/19/99	11,12,13,14,15

Second Shipment

S0002-2	16-18
S0002-3	19-21
S0002-4	22-24
S0003-2	25-27
S0004-2	28-30
S0005-1	31-35
S0005-2	36-38
S0005-3	39-40
S0005-4	41-42
S0007-29	43-47
S0008-2	48-50
S0024-2	51-53

Pairwise distances between taxa

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		1	2	3	4	5	6	7	8
1	Coryphopterus gl	-	0.46863	0.45580	0.45816	0.47835	0.47441	0.47638	0.48024
2	Eucyclogobius ne	239	-	0.04537	0.25000	0.28625	0.28437	0.28437	0.14630
3	Eucyclogobius ne	232	25	-	0.24646	0.28113	0.27547	0.27925	0.14471
4	Gillichthys mira	219	124	122	-	0.32790	0.32587	0.32587	0.25151
5	3Quietula ycauda	243	152	149	161	-	0.00924	0.00185	0.29356
6	2Quietula ycauda	241	151	146	160	5	-	0.00739	0.29167
7	1Quietula ycauda	242	151	148	160	1	4	-	0.29167
8	2Clevelandia ios	243	79	78	125	155	154	154	-
9	12Clevelandia io	242	78	77	124	155	154	154	7
10	43Clevelandia io	241	76	75	123	154	153	153	7
11	1Ilypnus gilbert	226	127	121	119	123	122	122	133
12	2Ilypnus gilbert	232	130	122	126	124	123	123	134
13	3Ilypnus gilbert	232	129	121	126	125	124	124	134
14	4Ilypnus gilbert	233	130	122	126	126	125	125	136
15	1UnknownLarva	215	175	179	173	174	173	173	186
16	2UnknownLarva	213	175	179	173	175	174	174	186
17	3UnknownLarva	241	154	150	161	12	11	11	159
18	4UnknownLarva	240	154	149	160	9	8	8	158
19	5UnknownLarva	239	153	148	159	8	7	7	157
20	6UnknownLarva	240	154	149	160	9	8	8	158
21	7UnknownLarva	239	154	149	160	10	9	9	158
22	8UnknownLarva	241	155	150	161	11	10	10	159
23	9UnknownLarva	240	154	149	160	9	8	8	158
24	10UnknownLarva	241	154	150	161	11	10	10	159
25	11UnknownLarva	240	153	148	159	11	9	10	157
26	12UnknownLarva	240	154	149	160	9	8	8	158
27	13UnknownLarva	241	154	150	161	9	8	8	157
28	14UnknownLarva	240	154	149	160	9	8	8	158
29	15UnknownLarva	240	154	149	160	9	8	8	158
30	16UnknownLarva	239	152	148	159	10	9	9	157
31	17UnknownLarva	240	153	148	160	10	9	9	159
32	18UnknownLarva	240	154	149	162	11	10	10	159
33	20UnknownLarva	240	154	149	160	9	8	8	158
34	21UnknownLarva	240	154	149	162	11	10	10	159
35	22UnknownLarva	240	154	149	160	9	8	8	158
36	23UnknownLarva	240	156	151	160	11	10	10	158
37	24UnknownLarva	240	154	149	160	9	8	8	158
38	25UnknownLarva	240	154	149	160	9	8	8	158
39	26UnknownLarva	240	154	149	160	9	8	8	158
40	27UnknownLarva	240	154	149	160	10	9	9	158
41	28UnknownLarva	194	138	136	139	6	7	5	144
42	29UnknownLarva	240	153	149	160	10	9	9	158
43	30UnknownLarva	241	153	148	160	10	9	9	157
44	31UnknownLarva	226	148	146	149	10	9	9	153
45	32UnknownLarva	241	154	149	160	10	9	9	158
46	33UnknownLarva	238	153	149	159	9	8	8	156
47	34UnknownLarva	241	155	150	161	10	9	9	159
48	35UnknownLarva	241	154	150	159	11	10	10	157
49	36UnknownLarva	240	154	149	160	9	8	8	158
50	37UnknownLarva	240	154	149	159	9	8	8	158
51	38UnknownLarva	240	154	149	160	9	8	8	158
52	39UnknownLarva	240	154	149	160	9	8	8	158
53	40UnknownLarva	240	154	149	160	9	8	8	158
54	41UnknownLarva	239	154	150	159	11	10	10	157
55	42UnknownLarva	241	155	150	161	11	10	10	159
56	43UnknownLarva	223	69	72	114	151	150	150	7
57	44UnknownLarva	246	77	78	126	156	155	155	10
58	45UnknownLarva	244	78	79	126	156	155	155	11
59	46UnknownLarva	246	80	77	122	155	154	154	10
60	47UnknownLarva	245	77	80	126	154	153	153	10
61	48UnknownLarva	239	154	149	160	9	8	8	158
62	49UnknownLarva	239	155	150	160	11	10	10	159
63	50UnknownLarva	214	145	140	153	8	7	7	150
64	51UnknownLarva	240	154	149	160	9	8	8	158
65	52UnknownLarva	239	154	149	159	10	9	9	158
66	53UnknownLarva	240	155	151	162	12	11	11	160

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

	9	10	11	12	13	14	15	16
1 Coryphopterus gl	0.47544	0.47441	0.46502	0.45669	0.45669	0.45776	0.46537	0.46104
2 Eucyclogobius ne	0.14444	0.14074	0.24951	0.24436	0.24248	0.24390	0.36842	0.36765
3 Eucyclogobius ne	0.14286	0.13915	0.23819	0.22976	0.22787	0.22932	0.37764	0.37684
4 Gillichthys mira	0.24850	0.24649	0.25373	0.25610	0.25610	0.25610	0.38530	0.38530
5 3Quietula ycauda	0.29245	0.29057	0.24165	0.23308	0.23496	0.23640	0.36632	0.36765
6 2Quietula ycauda	0.29057	0.28868	0.23969	0.23120	0.23308	0.23452	0.36421	0.36555
7 1Quietula ycauda	0.29057	0.28868	0.23969	0.23120	0.23308	0.23452	0.36421	0.36555
8 2Clevelandia ios	0.01284	0.01284	0.26337	0.25379	0.25379	0.25709	0.39407	0.39323
9 12Clevelandia io	-	0.00731	0.26036	0.25094	0.25094	0.25424	0.39030	0.38526
10 43Clevelandia io	4	-	0.25641	0.24906	0.24906	0.25235	0.39451	0.38947
11 1Ilypnus gilbert	132	130	-	0.00578	0.00963	0.00769	0.38546	0.38681
12 2Ilypnus gilbert	133	132	3	-	0.00737	0.00737	0.37107	0.37657
13 3Ilypnus gilbert	133	132	5	4	-	0.00737	0.37107	0.37238
14 4Ilypnus gilbert	135	134	4	4	4	-	0.37107	0.37238
15 1UnknownLarva	185	187	175	177	177	177	-	0.00816
16 2UnknownLarva	183	185	176	180	178	178	4	-
17 3UnknownLarva	159	158	122	123	124	125	173	174
18 4UnknownLarva	158	157	122	123	124	125	173	174
19 5UnknownLarva	157	156	121	122	123	124	173	174
20 6UnknownLarva	158	157	122	123	124	125	173	174
21 7UnknownLarva	158	157	123	124	125	126	173	174
22 8UnknownLarva	159	158	124	125	126	127	174	175
23 9UnknownLarva	158	157	122	123	124	125	173	174
24 10UnknownLarva	159	158	123	124	125	126	173	174
25 11UnknownLarva	157	156	121	122	123	124	172	173
26 12UnknownLarva	158	157	122	123	124	125	173	174
27 13UnknownLarva	157	156	123	124	125	126	172	173
28 14UnknownLarva	158	157	122	123	124	125	173	174
29 15UnknownLarva	158	157	122	123	124	125	173	174
30 16UnknownLarva	157	156	121	122	123	124	171	172
31 17UnknownLarva	159	158	122	123	124	125	172	173
32 18UnknownLarva	159	158	123	124	125	126	173	174
33 20UnknownLarva	158	157	122	123	124	125	173	174
34 21UnknownLarva	159	158	123	124	125	126	173	174
35 22UnknownLarva	158	157	122	123	124	125	173	174
36 23UnknownLarva	158	157	124	125	126	127	172	173
37 24UnknownLarva	158	157	122	123	124	125	173	174
38 25UnknownLarva	158	157	122	123	124	125	173	174
39 26UnknownLarva	158	157	122	123	124	125	173	174
40 27UnknownLarva	158	157	122	123	124	125	173	174
41 28UnknownLarva	145	143	118	119	119	120	144	145
42 29UnknownLarva	158	157	122	123	124	125	172	173
43 30UnknownLarva	157	156	123	124	125	126	174	175
44 31UnknownLarva	153	151	122	123	124	125	161	162
45 32UnknownLarva	158	157	122	123	124	125	173	174
46 33UnknownLarva	156	155	122	123	124	125	173	174
47 34UnknownLarva	159	158	123	124	125	126	174	175
48 35UnknownLarva	157	156	121	122	123	124	174	175
49 36UnknownLarva	158	157	122	123	124	125	173	174
50 37UnknownLarva	158	157	122	123	124	125	174	175
51 38UnknownLarva	158	157	122	123	124	125	173	174
52 39UnknownLarva	158	157	122	123	124	125	173	174
53 40UnknownLarva	158	157	122	123	124	125	173	174
54 41UnknownLarva	157	156	123	124	125	126	171	172
55 42UnknownLarva	159	158	123	124	125	126	172	173
56 43UnknownLarva	5	4	129	130	130	132	175	173
57 44UnknownLarva	9	9	132	133	133	135	187	187
58 45UnknownLarva	8	8	133	134	134	136	186	184
59 46UnknownLarva	9	9	133	134	134	136	183	183
60 47UnknownLarva	7	7	132	133	133	135	185	183
61 48UnknownLarva	158	157	121	122	123	124	172	173
62 49UnknownLarva	159	158	123	124	125	126	171	172
63 50UnknownLarva	151	150	119	120	121	122	160	161
64 51UnknownLarva	158	157	122	123	124	125	173	174
65 52UnknownLarva	158	157	122	123	124	125	172	173
66 53UnknownLarva	160	159	123	124	125	126	173	174

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		17	18	19	20	21	22	23	24
1	Coryphopterus gl	0.47441	0.47244	0.47047	0.47244	0.47047	0.47441	0.47244	0.47441
2	Eucyclogobius ne	0.29002	0.29002	0.28814	0.29002	0.29002	0.29190	0.29002	0.29002
3	Eucyclogobius ne	0.28302	0.28113	0.27925	0.28113	0.28113	0.28302	0.28113	0.28302
4	Gillichthys mira	0.32790	0.32587	0.32383	0.32587	0.32587	0.32790	0.32587	0.32790
5	3Quietula ycauda	0.02218	0.01664	0.01479	0.01664	0.01848	0.02033	0.01664	0.02033
6	2Quietula ycauda	0.02033	0.01479	0.01294	0.01479	0.01664	0.01848	0.01479	0.01848
7	1Quietula ycauda	0.02033	0.01479	0.01294	0.01479	0.01664	0.01848	0.01479	0.01848
8	2Clevelandia ios	0.30114	0.29924	0.29735	0.29924	0.29924	0.30114	0.29924	0.30114
9	12Clevelandia io	0.30000	0.29811	0.29623	0.29811	0.29811	0.30000	0.29811	0.30000
10	43Clevelandia io	0.29811	0.29623	0.29434	0.29623	0.29623	0.29811	0.29623	0.29811
11	1Ilypnus gilbert	0.23969	0.23969	0.23772	0.23969	0.24165	0.24361	0.23969	0.24165
12	2Ilypnus gilbert	0.23120	0.23120	0.22932	0.23120	0.23308	0.23496	0.23120	0.23308
13	3Ilypnus gilbert	0.23308	0.23308	0.23120	0.23308	0.23496	0.23684	0.23308	0.23496
14	4Ilypnus gilbert	0.23452	0.23452	0.23265	0.23452	0.23640	0.23827	0.23452	0.23640
15	1UnknownLarva	0.36421	0.36421	0.36421	0.36421	0.36421	0.36632	0.36421	0.36421
16	2UnknownLarva	0.36555	0.36555	0.36555	0.36555	0.36555	0.36765	0.36555	0.36555
17	3UnknownLarva	-	0.00555	0.00739	0.00555	0.00739	0.00924	0.00555	0.00555
18	4UnknownLarva	3	-	0.00185	0.00000	0.00185	0.00370	0.00000	0.00370
19	5UnknownLarva	4	1	-	0.00185	0.00370	0.00555	0.00185	0.00555
20	6UnknownLarva	3	0	1	-	0.00185	0.00370	0.00000	0.00370
21	7UnknownLarva	4	1	2	1	-	0.00555	0.00185	0.00555
22	8UnknownLarva	5	2	3	2	3	-	0.00370	0.00739
23	9UnknownLarva	3	0	1	0	1	2	-	0.00370
24	10UnknownLarva	3	2	3	2	3	4	2	-
25	11UnknownLarva	5	2	3	2	3	4	2	4
26	12UnknownLarva	3	0	1	0	1	2	0	2
27	13UnknownLarva	3	2	3	2	3	4	2	2
28	14UnknownLarva	3	0	1	0	1	2	0	2
29	15UnknownLarva	3	0	1	0	1	2	0	2
30	16UnknownLarva	2	1	2	1	2	3	1	1
31	17UnknownLarva	4	1	2	1	2	3	1	3
32	18UnknownLarva	5	2	3	2	3	4	2	4
33	20UnknownLarva	3	0	1	0	1	2	0	2
34	21UnknownLarva	5	2	3	2	3	4	2	4
35	22UnknownLarva	3	0	1	0	1	2	0	2
36	23UnknownLarva	5	2	3	2	3	4	2	4
37	24UnknownLarva	3	0	1	0	1	2	0	2
38	25UnknownLarva	3	0	1	0	1	2	0	2
39	26UnknownLarva	3	0	1	0	1	2	0	2
40	27UnknownLarva	4	1	2	1	2	3	1	3
41	28UnknownLarva	2	0	1	0	1	2	0	1
42	29UnknownLarva	3	2	2	2	3	4	2	2
43	30UnknownLarva	4	1	2	1	2	3	1	3
44	31UnknownLarva	2	1	2	1	2	3	1	0
45	32UnknownLarva	4	1	2	1	2	3	1	3
46	33UnknownLarva	5	2	1	2	3	4	2	4
47	34UnknownLarva	4	1	2	1	2	3	1	3
48	35UnknownLarva	5	4	3	4	5	6	4	4
49	36UnknownLarva	3	0	1	0	1	2	0	2
50	37UnknownLarva	5	2	1	2	3	4	2	4
51	38UnknownLarva	3	0	1	0	1	2	0	2
52	39UnknownLarva	3	0	1	0	1	2	0	2
53	40UnknownLarva	3	0	1	0	1	2	0	2
54	41UnknownLarva	3	2	3	2	3	4	2	2
55	42UnknownLarva	5	2	3	2	3	4	2	4
56	43UnknownLarva	154	153	152	153	153	154	153	154
57	44UnknownLarva	160	159	158	159	159	160	159	160
58	45UnknownLarva	160	159	158	159	159	160	159	160
59	46UnknownLarva	159	158	157	158	158	159	158	159
60	47UnknownLarva	158	157	156	157	157	158	157	158
61	48UnknownLarva	3	0	1	0	1	2	0	2
62	49UnknownLarva	5	2	3	2	3	4	2	4
63	50UnknownLarva	3	0	1	0	1	2	0	2
64	51UnknownLarva	3	0	1	0	1	2	0	2
65	52UnknownLarva	4	1	2	1	2	3	1	3
66	53UnknownLarva	4	3	4	3	4	5	3	3

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		25	26	27	28	29	30	31	32
1	Coryphopterus gl	0.47244	0.47244	0.47441	0.47244	0.47244	0.47140	0.47244	0.47244
2	Eucyclogobius ne	0.28814	0.29002	0.29002	0.29002	0.29002	0.28679	0.28814	0.29002
3	Eucyclogobius ne	0.27925	0.28113	0.28302	0.28113	0.28113	0.27977	0.27925	0.28113
4	Gillichthys mira	0.32383	0.32587	0.32790	0.32587	0.32587	0.32449	0.32587	0.32994
5	3Quietula ycauda	0.02033	0.01664	0.01664	0.01664	0.01664	0.01852	0.01848	0.02033
6	2Quietula ycauda	0.01664	0.01479	0.01479	0.01479	0.01479	0.01667	0.01664	0.01848
7	1Quietula ycauda	0.01848	0.01479	0.01479	0.01479	0.01479	0.01667	0.01664	0.01848
8	2Clevelandia ios	0.29735	0.29924	0.29735	0.29924	0.29924	0.29791	0.30114	0.30114
9	12Clevelandia io	0.29623	0.29811	0.29623	0.29811	0.29811	0.29679	0.30000	0.30000
10	43Clevelandia io	0.29434	0.29623	0.29434	0.29623	0.29623	0.29490	0.29811	0.29811
11	1Ilypnus gilbert	0.23772	0.23969	0.24165	0.23969	0.23969	0.23819	0.23969	0.24165
12	2Ilypnus gilbert	0.22932	0.23120	0.23308	0.23120	0.23120	0.22976	0.23120	0.23308
13	3Ilypnus gilbert	0.23120	0.23308	0.23496	0.23308	0.23308	0.23164	0.23308	0.23496
14	4Ilypnus gilbert	0.23265	0.23452	0.23640	0.23452	0.23452	0.23308	0.23452	0.23640
15	1UnknownLarva	0.36211	0.36421	0.36211	0.36421	0.36421	0.36076	0.36211	0.36421
16	2UnknownLarva	0.36345	0.36555	0.36345	0.36555	0.36555	0.36211	0.36345	0.36555
17	3UnknownLarva	0.00924	0.00555	0.00555	0.00555	0.00555	0.00370	0.00739	0.00924
18	4UnknownLarva	0.00370	0.00000	0.00370	0.00000	0.00000	0.00185	0.00185	0.00370
19	5UnknownLarva	0.00555	0.00185	0.00555	0.00185	0.00185	0.00370	0.00370	0.00555
20	6UnknownLarva	0.00370	0.00000	0.00370	0.00000	0.00000	0.00185	0.00185	0.00370
21	7UnknownLarva	0.00555	0.00185	0.00555	0.00185	0.00185	0.00370	0.00370	0.00555
22	8UnknownLarva	0.00739	0.00370	0.00739	0.00370	0.00370	0.00556	0.00555	0.00739
23	9UnknownLarva	0.00370	0.00000	0.00370	0.00000	0.00000	0.00185	0.00185	0.00370
24	10UnknownLarva	0.00739	0.00370	0.00370	0.00370	0.00370	0.00185	0.00555	0.00739
25	11UnknownLarva	-	0.00370	0.00739	0.00370	0.00370	0.00556	0.00555	0.00739
26	12UnknownLarva	2	-	0.00370	0.00000	0.00000	0.00185	0.00185	0.00370
27	13UnknownLarva	4	2	-	0.00370	0.00370	0.00185	0.00555	0.00739
28	14UnknownLarva	2	0	2	-	0.00000	0.00185	0.00185	0.00370
29	15UnknownLarva	2	0	2	0	-	0.00185	0.00185	0.00370
30	16UnknownLarva	3	1	1	1	1	-	0.00370	0.00556
31	17UnknownLarva	3	1	3	1	1	2	-	0.00555
32	18UnknownLarva	4	2	4	2	2	3	3	-
33	20UnknownLarva	2	0	2	0	0	1	1	2
34	21UnknownLarva	4	2	4	2	2	3	3	0
35	22UnknownLarva	2	0	2	0	0	1	1	2
36	23UnknownLarva	4	2	4	2	2	3	3	4
37	24UnknownLarva	2	0	2	0	0	1	1	2
38	25UnknownLarva	2	0	2	0	0	1	1	2
39	26UnknownLarva	2	0	2	0	0	1	1	2
40	27UnknownLarva	1	1	3	1	1	2	2	3
41	28UnknownLarva	2	0	1	0	0	1	1	2
42	29UnknownLarva	4	2	2	2	2	1	3	4
43	30UnknownLarva	3	1	3	1	1	2	2	3
44	31UnknownLarva	3	1	1	1	1	0	2	3
45	32UnknownLarva	3	1	3	1	1	2	2	3
46	33UnknownLarva	4	2	4	2	2	3	3	4
47	34UnknownLarva	3	1	3	1	1	2	2	3
48	35UnknownLarva	6	4	4	4	4	3	5	6
49	36UnknownLarva	2	0	2	0	0	1	1	2
50	37UnknownLarva	4	2	4	2	2	3	3	4
51	38UnknownLarva	2	0	2	0	0	1	1	2
52	39UnknownLarva	2	0	2	0	0	1	1	2
53	40UnknownLarva	2	0	2	0	0	1	1	2
54	41UnknownLarva	4	2	2	2	2	1	3	4
55	42UnknownLarva	4	2	4	2	2	3	3	4
56	43UnknownLarva	152	153	153	153	153	152	154	154
57	44UnknownLarva	158	159	158	159	159	158	160	160
58	45UnknownLarva	158	159	158	159	159	158	160	160
59	46UnknownLarva	157	158	157	158	158	157	159	159
60	47UnknownLarva	156	157	156	157	157	156	158	158
61	48UnknownLarva	2	0	2	0	0	1	1	2
62	49UnknownLarva	2	2	4	2	2	3	3	4
63	50UnknownLarva	2	0	1	0	0	1	1	2
64	51UnknownLarva	2	0	2	0	0	1	1	2
65	52UnknownLarva	3	1	3	1	1	2	2	3
66	53UnknownLarva	5	3	3	3	3	2	4	5

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

	33	34	35	36	37	38	39	40
1 Coryphopterus gl	0.47244	0.47244	0.47244	0.47244	0.47244	0.47244	0.47244	0.47244
2 Eucyclogobius ne	0.29002	0.29002	0.29002	0.29379	0.29002	0.29002	0.29002	0.29002
3 Eucyclogobius ne	0.28113	0.28113	0.28113	0.28491	0.28113	0.28113	0.28113	0.28113
4 Gillichthys mira	0.32587	0.32994	0.32587	0.32587	0.32587	0.32587	0.32587	0.32587
5 3Quietula ycauda	0.01664	0.02033	0.01664	0.02033	0.01664	0.01664	0.01664	0.01848
6 2Quietula ycauda	0.01479	0.01848	0.01479	0.01848	0.01479	0.01479	0.01479	0.01664
7 1Quietula ycauda	0.01479	0.01848	0.01479	0.01848	0.01479	0.01479	0.01479	0.01664
8 2Clevelandia ios	0.29924	0.30114	0.29924	0.29924	0.29924	0.29924	0.29924	0.29924
9 12Clevelandia io	0.29811	0.30000	0.29811	0.29811	0.29811	0.29811	0.29811	0.29811
10 43Clevelandia io	0.29623	0.29811	0.29623	0.29623	0.29623	0.29623	0.29623	0.29623
11 1Ilypnus gilbert	0.23969	0.24165	0.23969	0.24361	0.23969	0.23969	0.23969	0.23969
12 2Ilypnus gilbert	0.23120	0.23308	0.23120	0.23496	0.23120	0.23120	0.23120	0.23120
13 3Ilypnus gilbert	0.23308	0.23496	0.23308	0.23684	0.23308	0.23308	0.23308	0.23308
14 4Ilypnus gilbert	0.23452	0.23640	0.23452	0.23827	0.23452	0.23452	0.23452	0.23452
15 1UnknownLarva	0.36421	0.36421	0.36421	0.36211	0.36421	0.36421	0.36421	0.36421
16 2UnknownLarva	0.36555	0.36555	0.36555	0.36345	0.36555	0.36555	0.36555	0.36555
17 3UnknownLarva	0.00555	0.00924	0.00555	0.00924	0.00555	0.00555	0.00555	0.00739
18 4UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
19 5UnknownLarva	0.00185	0.00555	0.00185	0.00555	0.00185	0.00185	0.00185	0.00370
20 6UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
21 7UnknownLarva	0.00185	0.00555	0.00185	0.00555	0.00185	0.00185	0.00185	0.00370
22 8UnknownLarva	0.00370	0.00739	0.00370	0.00739	0.00370	0.00370	0.00370	0.00555
23 9UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
24 10UnknownLarva	0.00370	0.00739	0.00370	0.00739	0.00370	0.00370	0.00370	0.00555
25 11UnknownLarva	0.00370	0.00739	0.00370	0.00739	0.00370	0.00370	0.00370	0.00185
26 12UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
27 13UnknownLarva	0.00370	0.00739	0.00370	0.00739	0.00370	0.00370	0.00370	0.00555
28 14UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
29 15UnknownLarva	0.00000	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
30 16UnknownLarva	0.00185	0.00556	0.00185	0.00556	0.00185	0.00185	0.00185	0.00370
31 17UnknownLarva	0.00185	0.00555	0.00185	0.00555	0.00185	0.00185	0.00185	0.00370
32 18UnknownLarva	0.00370	0.00000	0.00370	0.00739	0.00370	0.00370	0.00370	0.00555
33 20UnknownLarva	-	0.00370	0.00000	0.00370	0.00000	0.00000	0.00000	0.00185
34 21UnknownLarva	2	-	0.00370	0.00739	0.00370	0.00370	0.00370	0.00555
35 22UnknownLarva	0	2	-	0.00370	0.00000	0.00000	0.00000	0.00185
36 23UnknownLarva	2	4	2	-	0.00370	0.00370	0.00370	0.00555
37 24UnknownLarva	0	2	0	2	-	0.00000	0.00000	0.00185
38 25UnknownLarva	0	2	0	2	0	-	0.00000	0.00185
39 26UnknownLarva	0	2	0	2	0	0	-	0.00185
40 27UnknownLarva	1	3	1	3	1	1	1	-
41 28UnknownLarva	0	2	0	0	0	0	0	1
42 29UnknownLarva	2	4	2	4	2	2	2	3
43 30UnknownLarva	1	3	1	3	1	1	1	2
44 31UnknownLarva	1	3	1	2	1	1	1	2
45 32UnknownLarva	1	3	1	3	1	1	1	2
46 33UnknownLarva	2	4	2	4	2	2	2	3
47 34UnknownLarva	1	3	1	3	1	1	1	2
48 35UnknownLarva	4	6	4	6	4	4	4	5
49 36UnknownLarva	0	2	0	2	0	0	0	1
50 37UnknownLarva	2	4	2	4	2	2	2	3
51 38UnknownLarva	0	2	0	2	0	0	0	1
52 39UnknownLarva	0	2	0	2	0	0	0	1
53 40UnknownLarva	0	2	0	2	0	0	0	1
54 41UnknownLarva	2	4	2	2	2	2	2	3
55 42UnknownLarva	2	4	2	4	2	2	2	3
56 43UnknownLarva	153	154	153	153	153	153	153	153
57 44UnknownLarva	159	160	159	159	159	159	159	159
58 45UnknownLarva	159	160	159	159	159	159	159	159
59 46UnknownLarva	158	159	158	158	158	158	158	158
60 47UnknownLarva	157	158	157	157	157	157	157	157
61 48UnknownLarva	0	2	0	2	0	0	0	1
62 49UnknownLarva	2	4	2	4	2	2	2	1
63 50UnknownLarva	0	2	0	2	0	0	0	1
64 51UnknownLarva	0	2	0	2	0	0	0	1
65 52UnknownLarva	1	3	1	3	1	1	1	2
66 53UnknownLarva	3	5	3	5	3	3	3	4

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		41	42	43	44	45	46	47	48
1	Coryphopterus gl	0.48500	0.47244	0.47441	0.48602	0.47441	0.46850	0.47441	0.47441
2	Eucyclogobius ne	0.33414	0.28814	0.28814	0.30453	0.29002	0.28814	0.29190	0.29002
3	Eucyclogobius ne	0.33010	0.28113	0.27925	0.30103	0.28113	0.28113	0.28302	0.28302
4	Gillichthys mira	0.37067	0.32587	0.32587	0.33333	0.32587	0.32383	0.32790	0.32383
5	3Quietula ycauda	0.01418	0.01848	0.01848	0.02016	0.01848	0.01664	0.01848	0.02033
6	2Quietula ycauda	0.01655	0.01664	0.01664	0.01815	0.01664	0.01479	0.01664	0.01848
7	1Quietula ycauda	0.01182	0.01664	0.01664	0.01815	0.01664	0.01479	0.01664	0.01848
8	2Clevelandia ios	0.34951	0.29924	0.29735	0.31677	0.29924	0.29545	0.30114	0.29735
9	12Clevelandia io	0.35194	0.29811	0.29623	0.31546	0.29811	0.29434	0.30000	0.29623
10	43Clevelandia io	0.34709	0.29623	0.29434	0.31134	0.29623	0.29245	0.29811	0.29434
11	1Ilypnus gilbert	0.28571	0.23969	0.24165	0.25103	0.23969	0.23969	0.24165	0.23772
12	2Ilypnus gilbert	0.28744	0.23120	0.23308	0.25257	0.23120	0.23120	0.23308	0.22932
13	3Ilypnus gilbert	0.28744	0.23308	0.23496	0.25462	0.23308	0.23308	0.23496	0.23120
14	4Ilypnus gilbert	0.28916	0.23452	0.23640	0.25615	0.23452	0.23452	0.23640	0.23265
15	1UnknownLarva	0.39669	0.36211	0.36632	0.37355	0.36421	0.36421	0.36632	0.36632
16	2UnknownLarva	0.39945	0.36345	0.36765	0.37500	0.36555	0.36555	0.36765	0.36765
17	3UnknownLarva	0.00473	0.00555	0.00739	0.00403	0.00739	0.00924	0.00739	0.00924
18	4UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
19	5UnknownLarva	0.00236	0.00370	0.00370	0.00403	0.00370	0.00185	0.00370	0.00555
20	6UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
21	7UnknownLarva	0.00236	0.00555	0.00370	0.00403	0.00370	0.00555	0.00370	0.00924
22	8UnknownLarva	0.00473	0.00739	0.00555	0.00605	0.00555	0.00739	0.00555	0.01109
23	9UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
24	10UnknownLarva	0.00236	0.00370	0.00555	0.00000	0.00555	0.00739	0.00555	0.00739
25	11UnknownLarva	0.00473	0.00739	0.00555	0.00605	0.00555	0.00739	0.00555	0.01109
26	12UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
27	13UnknownLarva	0.00236	0.00370	0.00555	0.00202	0.00555	0.00739	0.00555	0.00739
28	14UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
29	15UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
30	16UnknownLarva	0.00236	0.00185	0.00370	0.00000	0.00370	0.00556	0.00370	0.00556
31	17UnknownLarva	0.00236	0.00555	0.00370	0.00403	0.00370	0.00555	0.00370	0.00924
32	18UnknownLarva	0.00473	0.00739	0.00555	0.00605	0.00555	0.00739	0.00555	0.01109
33	20UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
34	21UnknownLarva	0.00473	0.00739	0.00555	0.00605	0.00555	0.00739	0.00555	0.01109
35	22UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
36	23UnknownLarva	0.00000	0.00739	0.00555	0.00403	0.00555	0.00739	0.00555	0.01109
37	24UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
38	25UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
39	26UnknownLarva	0.00000	0.00370	0.00185	0.00202	0.00185	0.00370	0.00185	0.00739
40	27UnknownLarva	0.00236	0.00555	0.00370	0.00403	0.00370	0.00555	0.00370	0.00924
41	28UnknownLarva	-	0.00473	0.00236	0.00236	0.00236	0.00473	0.00236	0.00709
42	29UnknownLarva	2	-	0.00555	0.00202	0.00555	0.00555	0.00555	0.00555
43	30UnknownLarva	1	3	-	0.00403	0.00370	0.00555	0.00370	0.00924
44	31UnknownLarva	1	1	2	-	0.00403	0.00605	0.00403	0.00403
45	32UnknownLarva	1	3	2	2	-	0.00555	0.00370	0.00924
46	33UnknownLarva	2	3	3	3	3	-	0.00555	0.00739
47	34UnknownLarva	1	3	2	2	2	3	-	0.00924
48	35UnknownLarva	3	3	5	2	5	4	5	-
49	36UnknownLarva	0	2	1	1	1	2	1	4
50	37UnknownLarva	2	3	3	3	3	2	3	4
51	38UnknownLarva	0	2	1	1	1	2	1	4
52	39UnknownLarva	0	2	1	1	1	2	1	4
53	40UnknownLarva	0	2	1	1	1	2	1	4
54	41UnknownLarva	1	2	3	0	3	4	3	4
55	42UnknownLarva	2	4	3	3	1	4	3	6
56	43UnknownLarva	143	153	152	148	153	151	154	152
57	44UnknownLarva	146	159	158	154	159	157	160	158
58	45UnknownLarva	146	159	158	154	159	157	160	158
59	46UnknownLarva	144	158	157	153	158	156	159	157
60	47UnknownLarva	144	157	156	152	157	155	158	156
61	48UnknownLarva	0	2	1	1	1	2	1	4
62	49UnknownLarva	2	4	3	3	3	4	3	6
63	50UnknownLarva	0	2	1	1	1	2	1	4
64	51UnknownLarva	0	2	1	1	1	2	1	4
65	52UnknownLarva	1	3	2	2	2	3	2	5
66	53UnknownLarva	2	3	4	1	4	5	4	5

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

	49	50	51	52	53	54	55	56
1 Coryphopterus gl	0.47244	0.47244	0.47244	0.47244	0.47244	0.47047	0.47441	0.47650
2 Eucyclogobius ne	0.29002	0.29002	0.29002	0.29002	0.29002	0.29002	0.29190	0.13968
3 Eucyclogobius ne	0.28113	0.28113	0.28113	0.28113	0.28113	0.28302	0.28302	0.14604
4 Gillichthys mira	0.32587	0.32383	0.32587	0.32587	0.32587	0.32383	0.32790	0.25110
5 3Quietula ycauda	0.01664	0.01664	0.01664	0.01664	0.01664	0.02033	0.02033	0.31198
6 2Quietula ycauda	0.01479	0.01479	0.01479	0.01479	0.01479	0.01848	0.01848	0.30992
7 1Quietula ycauda	0.01479	0.01479	0.01479	0.01479	0.01479	0.01848	0.01848	0.30992
8 2Clevelandia ios	0.29924	0.29924	0.29924	0.29924	0.29924	0.29735	0.30114	0.01397
9 12Clevelandia io	0.29811	0.29811	0.29811	0.29811	0.29811	0.29623	0.30000	0.00998
10 43Clevelandia io	0.29623	0.29623	0.29623	0.29623	0.29623	0.29434	0.29811	0.00798
11 1Ilypnus gilbert	0.23969	0.23969	0.23969	0.23969	0.23969	0.24165	0.24165	0.26987
12 2Ilypnus gilbert	0.23120	0.23120	0.23120	0.23120	0.23120	0.23308	0.23308	0.26860
13 3Ilypnus gilbert	0.23308	0.23308	0.23308	0.23308	0.23308	0.23496	0.23496	0.26860
14 4Ilypnus gilbert	0.23452	0.23452	0.23452	0.23452	0.23452	0.23640	0.23640	0.27216
15 1UnknownLarva	0.36421	0.36632	0.36421	0.36421	0.36421	0.36000	0.36211	0.40509
16 2UnknownLarva	0.36555	0.36765	0.36555	0.36555	0.36555	0.36134	0.36345	0.40046
17 3UnknownLarva	0.00555	0.00924	0.00555	0.00555	0.00555	0.00555	0.00924	0.31818
18 4UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
19 5UnknownLarva	0.00185	0.00185	0.00185	0.00185	0.00185	0.00555	0.00555	0.31405
20 6UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
21 7UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00555	0.31612
22 8UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00739	0.00739	0.31818
23 9UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
24 10UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00370	0.00739	0.31818
25 11UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00739	0.00739	0.31405
26 12UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
27 13UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00370	0.00739	0.31612
28 14UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
29 15UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
30 16UnknownLarva	0.00185	0.00556	0.00185	0.00185	0.00185	0.00185	0.00556	0.31470
31 17UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00555	0.31818
32 18UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00739	0.00739	0.31818
33 20UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
34 21UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00739	0.00739	0.31818
35 22UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
36 23UnknownLarva	0.00370	0.00739	0.00370	0.00370	0.00370	0.00370	0.00739	0.31612
37 24UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
38 25UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
39 26UnknownLarva	0.00000	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
40 27UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00555	0.31612
41 28UnknownLarva	0.00000	0.00473	0.00000	0.00000	0.00000	0.00236	0.00473	0.34793
42 29UnknownLarva	0.00370	0.00555	0.00370	0.00370	0.00370	0.00370	0.00739	0.31612
43 30UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00555	0.31405
44 31UnknownLarva	0.00202	0.00605	0.00202	0.00202	0.00202	0.00000	0.00605	0.32456
45 32UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00185	0.31612
46 33UnknownLarva	0.00370	0.00370	0.00370	0.00370	0.00370	0.00739	0.00739	0.31198
47 34UnknownLarva	0.00185	0.00555	0.00185	0.00185	0.00185	0.00555	0.00555	0.31818
48 35UnknownLarva	0.00739	0.00739	0.00739	0.00739	0.00739	0.00739	0.01109	0.31405
49 36UnknownLarva	-	0.00370	0.00000	0.00000	0.00000	0.00370	0.00370	0.31612
50 37UnknownLarva	2	-	0.00370	0.00370	0.00370	0.00739	0.00739	0.31612
51 38UnknownLarva	0	2	-	0.00000	0.00000	0.00370	0.00370	0.31612
52 39UnknownLarva	0	2	0	-	0.00000	0.00370	0.00370	0.31612
53 40UnknownLarva	0	2	0	0	-	0.00370	0.00370	0.31612
54 41UnknownLarva	2	4	2	2	2	-	0.00739	0.31405
55 42UnknownLarva	2	4	2	2	2	4	-	0.31818
56 43UnknownLarva	153	153	153	153	153	152	154	-
57 44UnknownLarva	159	159	159	159	159	158	160	6
58 45UnknownLarva	159	159	159	159	159	158	160	5
59 46UnknownLarva	158	158	158	158	158	157	159	7
60 47UnknownLarva	157	157	157	157	157	156	158	4
61 48UnknownLarva	0	2	0	0	0	2	2	153
62 49UnknownLarva	2	4	2	2	2	4	2	154
63 50UnknownLarva	0	2	0	0	0	2	2	149
64 51UnknownLarva	0	2	0	0	0	2	2	153
65 52UnknownLarva	1	3	1	1	1	3	3	153
66 53UnknownLarva	3	5	3	3	3	3	5	155

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		57	58	59	60	61	62	63	64
1	Coryphopterus gl	0.48425	0.48031	0.48425	0.48228	0.47140	0.47140	0.45923	0.47244
2	Eucyclogobius ne	0.14259	0.14444	0.14815	0.14259	0.29057	0.29245	0.30021	0.29002
3	Eucyclogobius ne	0.14471	0.14657	0.14286	0.14842	0.28166	0.28355	0.29046	0.28113
4	Gillichthys mira	0.25251	0.25251	0.24449	0.25251	0.32653	0.32653	0.34459	0.32587
5	3Quietula ycauda	0.29434	0.29434	0.29245	0.29057	0.01667	0.02037	0.01623	0.01664
6	2Quietula ycauda	0.29245	0.29245	0.29057	0.28868	0.01481	0.01852	0.01420	0.01479
7	1Quietula ycauda	0.29245	0.29245	0.29057	0.28868	0.01481	0.01852	0.01420	0.01479
8	2Clevelandia ios	0.01835	0.02018	0.01835	0.01835	0.29981	0.30171	0.31120	0.29924
9	12Clevelandia io	0.01645	0.01463	0.01645	0.01280	0.29868	0.30057	0.31328	0.29811
10	43Clevelandia io	0.01645	0.01463	0.01645	0.01280	0.29679	0.29868	0.31120	0.29623
11	1Ilypnus gilbert	0.26036	0.26233	0.26233	0.26036	0.23819	0.24213	0.25813	0.23969
12	2Ilypnus gilbert	0.25094	0.25283	0.25283	0.25094	0.22976	0.23352	0.24793	0.23120
13	3Ilypnus gilbert	0.25094	0.25283	0.25283	0.25094	0.23164	0.23540	0.25000	0.23308
14	4Ilypnus gilbert	0.25424	0.25612	0.25612	0.25424	0.23308	0.23684	0.25155	0.23452
15	1UnknownLarva	0.39451	0.39241	0.38608	0.39030	0.36287	0.36076	0.37123	0.36421
16	2UnknownLarva	0.39368	0.38737	0.38526	0.38526	0.36421	0.36211	0.37355	0.36555
17	3UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00556	0.00926	0.00609	0.00555
18	4UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
19	5UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00185	0.00556	0.00203	0.00185
20	6UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
21	7UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00185	0.00556	0.00203	0.00185
22	8UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00370	0.00741	0.00406	0.00370
23	9UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
24	10UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00370	0.00741	0.00406	0.00370
25	11UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00370	0.00370	0.00406	0.00370
26	12UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
27	13UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00370	0.00741	0.00203	0.00370
28	14UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
29	15UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
30	16UnknownLarva	0.29868	0.29868	0.29679	0.29490	0.00186	0.00557	0.00203	0.00185
31	17UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00185	0.00556	0.00203	0.00185
32	18UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00370	0.00741	0.00406	0.00370
33	20UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
34	21UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00370	0.00741	0.00406	0.00370
35	22UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
36	23UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00370	0.00741	0.00406	0.00370
37	24UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
38	25UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
39	26UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
40	27UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00185	0.00185	0.00203	0.00185
41	28UnknownLarva	0.35437	0.35437	0.34951	0.34951	0.00000	0.00474	0.00000	0.00000
42	29UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00370	0.00741	0.00406	0.00370
43	30UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00185	0.00556	0.00203	0.00185
44	31UnknownLarva	0.31753	0.31753	0.31546	0.31340	0.00202	0.00606	0.00223	0.00202
45	32UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00185	0.00556	0.00203	0.00185
46	33UnknownLarva	0.29623	0.29623	0.29434	0.29245	0.00370	0.00741	0.00406	0.00370
47	34UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00185	0.00556	0.00203	0.00185
48	35UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00741	0.01111	0.00811	0.00739
49	36UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
50	37UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00370	0.00741	0.00406	0.00370
51	38UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
52	39UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
53	40UnknownLarva	0.30000	0.30000	0.29811	0.29623	0.00000	0.00370	0.00000	0.00000
54	41UnknownLarva	0.29811	0.29811	0.29623	0.29434	0.00370	0.00741	0.00406	0.00370
55	42UnknownLarva	0.30189	0.30189	0.30000	0.29811	0.00370	0.00370	0.00406	0.00370
56	43UnknownLarva	0.01198	0.00998	0.01397	0.00798	0.31677	0.31884	0.32112	0.31612
57	44UnknownLarva	-	0.01645	0.01463	0.01463	0.30057	0.30246	0.31535	0.30000
58	45UnknownLarva	9	-	0.02011	0.01280	0.30057	0.30246	0.31535	0.30000
59	46UnknownLarva	8	11	-	0.01828	0.29868	0.30057	0.31120	0.29811
60	47UnknownLarva	8	7	10	-	0.29679	0.29868	0.31120	0.29623
61	48UnknownLarva	159	159	158	157	-	0.00371	0.00000	0.00000
62	49UnknownLarva	160	160	159	158	2	-	0.00407	0.00370
63	50UnknownLarva	152	152	150	150	0	2	-	0.00000
64	51UnknownLarva	159	159	158	157	0	2	0	-
65	52UnknownLarva	159	159	158	157	1	3	1	1
66	53UnknownLarva	161	161	160	159	3	5	3	3

Pairwise distances between taxa (continued)

Below diagonal: Total character differences
Above diagonal: Mean character differences (adjusted for missing data)

		65	66
1	Coryphopterus gl	0.47140	0.47244
2	Eucyclogobius ne	0.29057	0.29190
3	Eucyclogobius ne	0.28166	0.28491
4	Gillichthys mira	0.32449	0.32994
5	3Quietula ycauda	0.01852	0.02218
6	2Quietula ycauda	0.01667	0.02033
7	1Quietula ycauda	0.01667	0.02033
8	2Clevelandia ios	0.29981	0.30303
9	12Clevelandia io	0.29868	0.30189
10	43Clevelandia io	0.29679	0.30000
11	1Ilypnus gilbert	0.24016	0.24165
12	2Ilypnus gilbert	0.23164	0.23308
13	3Ilypnus gilbert	0.23352	0.23496
14	4Ilypnus gilbert	0.23496	0.23640
15	1UnknownLarva	0.36287	0.36421
16	2UnknownLarva	0.36421	0.36555
17	3UnknownLarva	0.00741	0.00739
18	4UnknownLarva	0.00185	0.00555
19	5UnknownLarva	0.00370	0.00739
20	6UnknownLarva	0.00185	0.00555
21	7UnknownLarva	0.00370	0.00739
22	8UnknownLarva	0.00556	0.00924
23	9UnknownLarva	0.00185	0.00555
24	10UnknownLarva	0.00556	0.00555
25	11UnknownLarva	0.00556	0.00924
26	12UnknownLarva	0.00185	0.00555
27	13UnknownLarva	0.00556	0.00555
28	14UnknownLarva	0.00185	0.00555
29	15UnknownLarva	0.00185	0.00555
30	16UnknownLarva	0.00370	0.00370
31	17UnknownLarva	0.00370	0.00739
32	18UnknownLarva	0.00556	0.00924
33	20UnknownLarva	0.00185	0.00555
34	21UnknownLarva	0.00556	0.00924
35	22UnknownLarva	0.00185	0.00555
36	23UnknownLarva	0.00556	0.00924
37	24UnknownLarva	0.00185	0.00555
38	25UnknownLarva	0.00185	0.00555
39	26UnknownLarva	0.00185	0.00555
40	27UnknownLarva	0.00370	0.00739
41	28UnknownLarva	0.00236	0.00473
42	29UnknownLarva	0.00556	0.00555
43	30UnknownLarva	0.00370	0.00739
44	31UnknownLarva	0.00404	0.00202
45	32UnknownLarva	0.00370	0.00739
46	33UnknownLarva	0.00556	0.00924
47	34UnknownLarva	0.00370	0.00739
48	35UnknownLarva	0.00926	0.00924
49	36UnknownLarva	0.00185	0.00555
50	37UnknownLarva	0.00556	0.00924
51	38UnknownLarva	0.00185	0.00555
52	39UnknownLarva	0.00185	0.00555
53	40UnknownLarva	0.00185	0.00555
54	41UnknownLarva	0.00556	0.00555
55	42UnknownLarva	0.00556	0.00924
56	43UnknownLarva	0.31677	0.32025
57	44UnknownLarva	0.30057	0.30377
58	45UnknownLarva	0.30057	0.30377
59	46UnknownLarva	0.29868	0.30189
60	47UnknownLarva	0.29679	0.30000
61	48UnknownLarva	0.00186	0.00556
62	49UnknownLarva	0.00557	0.00926
63	50UnknownLarva	0.00203	0.00609
64	51UnknownLarva	0.00185	0.00555
65	52UnknownLarva	-	0.00741
66	53UnknownLarva	4	-

Appendix G-2

Review of Dr. Jacobs' Analysis

by

Giacomo Bernardi, Ph.D
Assistant Professor of Biology
University of California Santa Cruz
February 20, 2001

Michael Thomas
Regional Water Quality Control Board
81 Higuera Street, Suite 200
San Luis Obispo, CA 93401

RE: Comments on the molecular identification of presumed tidewater goby larval samples

Santa Cruz, February 20 2001

Dear Mr. Thomas,

Please find enclosed my comments on the molecular work that was done on goby larvae. As you will see, I find the molecular results very convincing. Yet, I also tried to explore other possibilities that may explain the discrepancy between morphological and molecular results. Briefly, both introgression and hybridization may account for these results. I don't know how far you would like to push this investigation, but if necessary, it is possible to do genetic tests to determine if either introgression or hybridization have occurred.

Sincerely,

Giacomo Bernardi
Assistant Professor of Biology
University of California Santa Cruz

Michael Thomas
Regional Water Quality Control Board
81 Higuera Street, Suite 200
San Luis Obispo, CA 93401

RE: Comments on the molecular identification of presumed tidewater goby larval samples

Santa Cruz, February 20 2001

In this comment, I will briefly describe my expertise, then comment on the molecular work on larval fishes as presented in the report, and finally propose a possible explanation for the inconsistency between molecular and morphological results.

Personal background: My own work is on fish molecular genetics (past fifteen years). Although I don't work on tidewater gobies, I am familiar with the work of Drs. Mike Dawson and David Jacobs. I work on several California fish species including two gobies of the genus *Gillichthys*. The specific techniques described in the report are routinely used in my laboratory.

Comments on the results presented in the report: Briefly, the results presented are unambiguous. The mitochondrial DNA from most of the individuals is similar to the shadow goby's (two were unidentified species, one did not amplify). Importantly, it is similar but not identical, thus removing the possibility of PCR contamination by previously used samples (this is mentioned in the report). This result is also statistically well supported as evidenced by high bootstrap values. It is therefore justified to say that these individuals have shadow goby mitochondrial DNA.

To be extremely rigorous, it would be possible to do statistical tests (Kishino and Hasegawa test, or T-PTP test) to demonstrate that these data actually reject the possibility that these samples have tidewater goby mtDNA. I can't run the tests, as raw data were unavailable. It is, however, very unlikely that I would obtain a different result as the bootstrap values presented here are very high, and the genetic distances between species are high also. Therefore, the results are very convincing.

I understand that the fish larvae sent to Dr. Jacobs were morphologically identified as tidewater gobies. Thus two explanations can satisfy this inconsistency: 1) the morphological analysis was flawed. This may be due to a wrong identification or using a wrong key, 2) the genetic technique is flawed. Not being a specialist on larval morphology, I can't assess the likelihood of a mistake in the morphological identification. Thus I will limit myself to a comment on the genetic aspect of this problem.

There are two situations I can think of where we could find this type of morphological/genetic inconsistency. It is important at this point to remember that the DNA sequenced by Dr. Jacobs is maternally inherited. In vertebrates, mitochondrial DNA is only transmitted through the mother.

Situation 1. Introgression or capture. The nuclear DNA (chromosomes) of the larvae collected is of a tidewater goby and the mt DNA of a shadow goby (or of an unidentified goby for two samples). In this case, all the nuclear DNA belongs to the tidewater goby (as opposed to situation 2). This scenario is the result of ancient hybridization events.

Situation 2. Hybridization. The larvae analyzed by Dr. Jacobs are the product of a male tidewater goby with a female shadow goby (or in two cases a female of an unidentified species). If what we are observing is hybridization, it is not surprising to see only one type of cross (male tidewater goby, female shadow goby) and not the reverse, as in natural hybridizations, the vast majority of crosses are only in one direction.

In general, introgression and hybridization occur when one species is rare and can't find appropriate mates as often as needed. Although these two scenarios may seem far-fetched, we have observed both phenomena happening in two species of California minnows (hitch and roach) in my lab. Importantly, in both cases the actual animal looks like one species, while its mitochondrial DNA looks like the other species. Thus in this case, morphology and mitochondrial sequence are at odds, very much like the situation presented here.

If necessary, it is possible to test these hypotheses by sequencing some nuclear DNA to determine if indeed these larvae contain any tidewater goby DNA.

In conclusion: Fishes examined by Dr. Jacobs are unequivocally not pure tidewater gobies as their mitochondrial DNA is not of tidewater gobies. Since they morphologically resemble tidewater goby, they may be the result of introgression or hybridization with shadow gobies or in two cases with another unidentified species.

Dr. Giacomo Bernardi
Assistant Professor of Biology
University of California Santa Cruz

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix H

Impingement Abundance Weekly Surveys and Impingement Estimates for Selected Species

APPENDIX H IMPINGEMENT ABUNDANCE WEEKLY SURVEYS AND IMPINGEMENT ESTIMATES FOR SELECTED SPECIES

The tables in this appendix contain two types of Morro Bay Power Plant impingement data. The first set of tables, H1-1 through H1-53, gives the following information: (1) the weekly impingement survey data from for all species from September 9, 1999 through September 7, 2000, and (2) the pump operating status (i.e., hours of operation during the 24-hour sampling period). The second set of tables, H2-1 through H2-20, provides estimates of the weekly numbers and biomass of selected fishes and invertebrates impinged at the MBPP.

Table H1-1. Morro Bay Power Plant Impingement Abundance Survey 01, September 9, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	530	790.1			
Teleosts							
Apodichthys flavidus	penpoint gunnel				1	224	51.9
Atherinops affinis	topsmelt				1	124	17.6
Citharichthys sordidus	Pacific sanddab				1	63	4.7
Clupea pallasii	Pacific herring				1	118	16.8
Cymatogaster aggregata	shiner surfperch				2	55 - 87	3.3 - 15.2
Engraulis mordax	northern anchovy				2	83 - 105	5.4 - 12.3
Hexagrammos decagrammus	kelp greenling				1	123	33.7
Oligocottus snyderi	fluffy sculpin				1	46	2.6
Phanerodon furcatus	white surfperch				1	178	
Sardinops sagax	Pacific sardine				2	150 - 153	34.4 - 36.4
Scorpaenichthys marmoratus	cabezon	2	89 - 106	16.2 - 26.0	1	73	9.4
Sebastes atrovirens (juv.)	kelp rockfish				1	162	107.5
Sebastes melanops	black rockfish				2	60 - 71	4.7 - 7.2
Sebastes spp.	rockfishes				1	22	0.2
Symphurus atricauda	California tonguefish				2	74 - 92	3.4 - 6.7
Crabs							
Cancer antennarius	brown rock crab	5	30 - 118	4.8 - 333.5	3	38 - 83	11.1 - 127.1
Cancer gracilis	slender rock crab				1	39	4.3
Cancer jordani	hairy rock crab	5	14 - 34	0.9 - 9.2			
Cancer magister	Dungeness crab				1	51	16.6
Cancer productus	red rock crab	1	32	5.2	3	17 - 27	0.9 - 2.1
Cancer spp.	cancer crabs	4	17 - 21	1.6 - 2.0	3	10 - 18	0.2 - 3.8
Loxorhynchus crispatus	moss crab				1	51	70.0
Pachycheles spp.	porcelain crabs				1	16	-
Pachygrapsus crassipes	striped shore crab	3	28 - 29	9.7 - 11.8	2	10 - 21	1.1 - 3.9
Portunus xantusii	Xantus' swimming crab	9	38 - 55	6.0 - 20.6	25	34 - 60	5.3 - 23.5
Pugettia producta	northern kelp crab				11	9 - 56	0.8 - 88.8
Shrimps							
Crangon spp.	bay shrimp	1	14	4.6	6	10 - 12	1.1 - 2.6
Pandalopsis dispar	sidestriped shrimp				1	21	3.1
Pandalus spp.	unidentified shrimp				1	-	-
Cephalopods							
Loligo opalescens	market squid				2	48 - 61	3.2 - 7.1
Octopus spp.	octopus	2	109 - 310	172.4 - 182.5			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	8	0.4	6	9 - 40	0.5 - 24.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0001	09/09/99	09/10/99	0	0	24	24	24	24	24	24

Table H1-2. Morro Bay Power Plant Impingement Abundance Survey 02, September 16, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
	bat ray				1	191	403.6
Torpedo californica	Pacific electric ray				1	200	120.6
Teleosts							
	Pacific sanddab				1	72	3.3
Engraulis mordax	northern anchovy				1	103	11.4
Porichthys notatus	plainfin midshipmen				2	42 - 46	1.2 – 1.4
Sardinops sagax	Pacific sardine				1	150	20.3
Sebastes melanops	black rockfish				2	62 - 71	4.8 - 11.7
Symphurus atricauda	California tonguefish	1	87	6.3	4	85 - 104	3.5 - 14.5
Syngnathus leptorhynchus	bay pipefish				1	103	0.7
Syngnathus spp.	pipefishes	1	338	4.7			
Crabs							
Cancer antennarius	brown rock crab				1	71	74.5
Cancer jordani	hairy rock crab	6	18 - 40	1.4 - 18.8	5	11 - 19	1.0 - 6.0
Cancer magister	Dungeness crab	1	30	3.5			
Cancer productus	red rock crab	3	18 - 40	0.9 - 12.0	8	13 - 33	0.7 - 9.6
Cancer spp.	cancer crabs	1	-	-	2	10 - 18	2.0 - 4.7
Loxorhynchus crispatus	moss crab	2	14 - 42	2.6 - 31.6			
Pachygrapsus crassipes	striped shore crab				1	19	4.4
Portunus xantusii	Xantus' swimming crab	29	32 - 63	6.5 - 32.0	30	35 - 58	7.4 - 31.2
Pugettia producta	northern kelp crab	1	15	1.1	10	15 - 58	1.7 - 71.1
Shrimps							
C nigricauda	black-tailed bay shrimp	2	-	2.8 - 3.2			
Crangon spp.	bay shrimp				1	1	1.2
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	12 - 16	1.5	1	35	22.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0002	09/16/99	09/17/99	24	24	24	24	24	24	24	24

Table H1-3. Morro Bay Power Plant Impingement Abundance Survey 03, September 23, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				5	375	177.5
Platyrhinoidis triseriata	thornback				4	222 - 645	9.6 - 1635.5
Teleosts							
Atherinops affinis	topsmelt	1	94	7.3	1	52	1.0
Chilara taylori	spotted cusk-eel				1	161	17.2
Citharichthys sordidus	Pacific sanddab				1	129	17.4
Engraulis mordax	northern anchovy				4	64 - 112	2.6 - 14.6
Gobiesox spp.	clingfishes				1	32	0.8
Leptocottus armatus	Pacific staghorn sculpin	2	101	16.1	1	98	14.9
Scorpaenichthys marmoratus	cabezon	1	204	120.0			
Sebastes spp.	rockfishes				1	580	330.0
Symphurus atricauda	California tonguefish	7	67 - 97	2.2 - 7.6	12	66 - 100	2.9 - 8.4
Crabs							
Cancer antennarius	brown rock crab				4	18 - 91	1.6 - 143.4
Cancer gracilis	slender rock crab				2	19 - 20	1.9 - 1.9
Cancer jordani	hairy rock crab	4	10 - 19	0.3 - 1.9	7	15 - 33	1.0 - 9.9
Cancer magister	Dungeness crab				3	14 - 48	0.9 - 18.2
Cancer magister/gracilis	cancer crabs				2	11 - 14	0.8 - 1.3
Cancer productus	red rock crab				3	19 - 116	1.7 - 212.4
Cancer spp.	cancer crabs	2	13 - 19	0.8 - 2.4			
Portunus xantusii	Xantus' swimming crab	37	35 - 56	5.4 - 21.2	50	32 - 68	4.1 - 40.3
Pugettia producta	northern kelp crab				3	12 - 26	0.6 - 7.5
Pugettia richii	cryptic kelp crab	1	7	0.8	1	11	0.9
Shrimps							
Crangon spp.	bay shrimp	1	11	1.6			
Pandalopsis dispar	sidestriped shrimp				1	21	5.5
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				2	22 - 24	6.3 - 6.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0003	09/23/99	09/24/99	24	23	24	24	24	24	24	24

Table H1-4. Morro Bay Power Plant Impingement Abundance Survey 04, September 30, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				2	470 - 570	366.6 - 562.3
Platyrhinoidis triseriata	thornback				1	349	264.7
Teleosts							
Citharichthys stigmaeus	speckled sanddab				3	66 - 86	4.5 - 12.0
Cymatogaster aggregata	shiner surfperch				1	95	20.7
Leptocottus armatus	Pacific staghorn sculpin	2	103 - 117	20.0 - 22.7	1	54	7.1
Parophrys vetulus	English sole	1	117	26.9			
Sardinops sagax	Pacific sardine				1	144	30.5
Scorpaenichthys marmoratus	cabezon	1	125	37.1	1	-	-
Sebastes melanops	black rockfish				1	42	2.0
Symphurus atricauda	California tonguefish				2	80 - 87	4.6 - 4.8
Syngnathus leptorhynchus	bay pipefish	1	181	4.0			
Crabs							
Cancer antennarius	brown rock crab	5	21 - 103	2.1 - 169.0	3	26 - 71	5.5 - 69.4
Cancer gracilis	slender rock crab				2	12 - 20	0.5 - 1.2
Cancer jordani	hairy rock crab	3	22 - 29	2.2 - 5.5	1	15	1.2
Cancer productus	red rock crab	2	28 - 34	2.8 - 5.0	4	19 - 39	1.0 - 7.7
Cancer spp.	cancer crabs				1	15	0.5
Portunus xantusii	Xantus' swimming crab	9	36 - 67	4.8 - 39.5	13	34 - 48	4.6 - 12.3
Pugettia producta	northern kelp crab	2	8 - 14	0.5 - 3.2	5	12 - 59	1.0 - 83.1
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	-	1.0
Heptacarpus spp.	tidepool shrimps				1	11	0.4
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	18 - 19	2.2 - 3.2			

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0004	09/30/99	10/01/99	24	24	24	2	24	24	24	24

Table H1-5. Morro Bay Power Plant Impingement Abundance Survey 05, October 07, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	500	424.0
Platyrhinoidis triseriata	thornback				2	470 - 655	500.9 - 1814.5
Teleosts							
Apodichthys flavidus	penpoint gunnel	1	170	16.3			
Artedius spp.	sculpins	1	41	1.7			
Atherinops affinis	topsmelt				1	150	36.4
Hyperprosopon argenteum	walleye surfperch				1	68	7.6
Leptocottus armatus	Pacific staghorn sculpin	2	118 - 133	25.9 - 39.9	3	104 - 117	18.0 - 25.5
Pleuronichthys coenosus	c-o turbot	1	48	1.9			
Sardinops sagax	Pacific sardine	2	136 - 155	22.6 - 44.3	4	135 - 181	20.8 - 76.5
Symphurus atricauda	California tonguefish	2	84 - 101	4.7 - 8.8	4	85 - 94	4.9 - 7.5
Syngnathus californiensis	kelp pipefish	1	194	4.4			
Crabs							
Cancer antennarius	brown rock crab	1	63	50.1	2	30 - 111	4.9 - 168.7
Cancer jordani	hairy rock crab	1	17	1.4	1	14	0.7
Cancer productus	red rock crab	1	45	13.2	1	54	21.0
Cancer spp.	cancer crabs	1	-	0.9			
Hemigrapsus oregonensis	yellow shore crab				1	21	3.5
Loxorhynchus crispatus	moss crab	1	9	0.5			
Pachycheles pubescens	pubescent porcelain crab				3	5 - 15	0.2 – 4.3
Portunus xantusii	Xantus' swimming crab	13	38 - 60	5.6 - 25.4	23	34 - 61	4.9 - 29.7
Pugettia producta	northern kelp crab				4	8 - 41	0.2 - 25.8
Shrimp							
Crangon spp.	bay shrimp	3	8 - 10	0.7 - 1.7			
Heptacarpus spp.	tidepool shrimps				1	13	0.5
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	20	4.6	3	10 - 20	0.4 - 4.1

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0005	10/07/99	10/08/99	24	24	24	24	24	24	24	24

Table H1-6. Morro Bay Power Plant Impingement Abundance Survey 06, October 14, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Apodichthys flavidus	penpoint gunnel				1	130	7.7
Chilara taylori	spotted cusk-eel	1	155	16.5			
Cymatogaster aggregata	shiner surfperch				2	110 - 113	34.6 - 36.0
Engraulis mordax	northern anchovy				1	80	4.2
Ophiodon elongatus	lingcod				1	115	8.3
Porichthys notatus	plainfin midshipmen				1	106	15.5
Scorpaenichthys marmoratus	cabezon				2	131 - 168	59.7 - 125.0
Sebastes melanops	black rockfish				1	61	-
Symphurus atricauda	California tonguefish				1	87	6.0
Syngnathus leptorhynchus	bay pipefish	1	134	0.4			
Crabs							
Cancer antennarius	brown rock crab	4	26 - 111	4.4 - 266.1	3	50 - 80	11.7 - 111.5
Cancer jordani	hairy rock crab	1	29	5.0			
Cancer productus	red rock crab				1	45	11.3
Loxorhynchus crispatus	moss crab	1	12	2.2			
Pachygrapsus crassipes	striped shore crab				2	18 - 23	1.4 - 6.0
Portunus xantusii	Xantus' swimming crab	2	33 - 46	5.5 - 5.9	6	35 - 60	4.4 - 31.3
Pugettia producta	northern kelp crab				3	10 - 20	0.6 - 3.5
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	10	0.6

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0006	10/14/99	10/15/99	24	24	23	23	22	24	24	24

Table H1-7. Morro Bay Power Plant Impingement Abundance Survey 07, October 21, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	505	378.2
Platyrhinoidis triseriata	thornback				1	480	648.5
Teleosts							
Atherinops affinis	topsmelt				1	81	5.3
Citharichthys sordidus	Pacific sanddab				1	90	12.5
Citharichthys stigmaeus	speckled sanddab	2	73 - 78	7.1 - 8.9	2	63 - 89	5.3 - 13.7
Embiotoca jacksoni	black surfperch				1	100	34.8
Engraulis mordax	northern anchovy	1	71	2.9	3	105 - 124	11.1 - 18.5
Ophiodon elongatus	lingcod	1	141	16.8			
Parophrys vetulus	English sole				1	90	12.9
Sardinops sagax	Pacific sardine	1	154	36.1	2	143 - 185	34.5 - 76.5
Sebastes auriculatus	brown rockfish				1	145	73.3
Symphurus atricauda	California tonguefish	11	77 - 100	5.2 - 9.5	7	79 - 97	5.0 - 9.2
Syngnathus leptorhynchus	bay pipefish				1	176	2.6
Syngnathus spp.	pipefishes				2	158	1.5
Crabs							
Cancer antennarius	brown rock crab	2	30 - 56	6.9 - 24.2	2	42 - 67	19.0 - 61.3
Cancer jordani	hairy rock crab	6	14 - 27	1.0 - 4.1	2	15 - 17	2.1
Cancer magister	Dungeness crab	1	16	0.5	1	18	1.7
Cancer productus	red rock crab	2	27 - 47	3.2 - 13.2	1	14	1.9
Cancer spp.	cancer crabs	4	9 - 29	0.3 - 5.6	4	8 - 17	1.4 - 3.0
Loxorhynchus crispatus	moss crab				1	16	0.5
Pachygrapsus crassipes	striped shore crab				1	12	2.0
Portunus xantusii	Xantus' swimming crab	6	41 - 70	8.5 - 48.0	3	41 - 43	8.3 - 78.0
Pugettia producta	northern kelp crab	1	23	6.2	2	20 - 63	4.4 - 80.0
Pugettia richii	cryptic kelp crab				1	12	1.8
Shrimps							
Crangon spp.	bay shrimp	4	10 - 11	0.3 - 1.9			
Heptacarpus spp.	tidepool shrimps	2	9 - 10	0.5 - 2.2			
Pandalus platyceros	spot shrimp				1	117	79.1
Cephalopods							
Loligo opalescens	market squid	1	130	42.1			
Octopus spp.	octopus				1	27	8.7
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	14	0.9	4	10 - 12	0.6 - 5.8

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0007	10/21/99	10/22/99	23	23	24	24	24	24	24	24

Table H1-8. Morro Bay Power Plant Impingement Abundance Survey 08, October 28, 1999.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	479	279.6
Teleosts							
Artedius lateralis	smoothhead sculpin	1	82	12.1			
Engraulis mordax	northern anchovy				1	92	5.9
Leptocottus armatus	Pacific staghorn sculpin				1	110	17.6
Sardinops sagax	Pacific sardine				1	136	21.4
Scorpaenichthys marmoratus	cabezon	1	143	64.0			
Sebastes melanops	black rockfish				2	38 - 46	1.3 - 1.9
Symphurus atricauda	California tonguefish				1	100	10.4
Syngnathus leptorhynchus	bay pipefish				1	123	0.8
Syngnathus spp.	pipefishes				1	233	4.4
Crabs							
Cancer jordani	hairy rock crab				3	22 - 44	0.4 - 18.4
Cancer spp.	cancer crabs				3	1 - 10	0.3 - 0.5
Loxorhynchus crispatus	moss crab	1	10	0.4			
Portunus xantusii	Xantus' swimming crab				1	58	25.3
Pugettia producta	northern kelp crab				1	14	1.1
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	1	12	0.9			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				3	6 - 35	0.2 - 13.5

* N = 3, Cycles 3-6 not sampled. Heavy amounts od debris required continuous screen washing, so samples could not be collected.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0008	10/28/99	10/29/99	24	24	23	24	24	24	24	24

Table H1-9. Morro Bay Power Plant Impingement Abundance Survey 09, November 04, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				2	630 - 640	1500.0 - 1510.0
Teleosts							
Artedius lateralis	smoothhead sculpin				1	64	5.5
Chilara taylori	spotted cusk-eel	1	185	22.8			
Citharichthys sordidus	Pacific sanddab	1	93	12.8	1	81	9.6
Citharichthys stigmaeus	speckled sanddab	1	91	11.9			
Gibbonsia metzi	striped kelpfish				1	137	28.5
Leptocottus armatus	Pacific staghorn sculpin				2	73 - 133	7.5 - 37.1
Sebastes atrovirens	kelp rockfish				1	180	12.4
Sebastes chrysomelas	black and yellow rockfish	1	67	8.7	1	93	20.1
Symphurus atricauda	California tonguefish	20	75 - 105	3.70 - 11.4	24	72 - 112	3.4 - 9.0
Syngnathus californiensis	kelp pipefish	1	366	19.1			
Syngnathus leptorhynchus	bay pipefish	1	233	3.7	2	166 - 205	3.8 - 5.5
Syngnathus spp.	pipefishes	2*	238	3.8			
Crabs							
Cancer antennarius	brown rock crab	3	24 - 51	0.9 - 29.0	1	35	10.8
Cancer gracilis	slender rock crab				1	13	0.5
Cancer jordani	hairy rock crab	6	17 - 21	1.0 - 2.1	1	18	2.8
Cancer productus	red rock crab	1	39	7.3			
Pachygrapsus crassipes	striped shore crab				1	31	7.0
Portunus xantusii	Xantus' swimming crab	4	42 - 61	7.1 - 27.7	5	34 - 69	3.4 - 41.9
Pugettia producta	northern kelp crab	1	32	20.0	4	8 - 39	0.4 - 28.9
Shrimps							
Heptacarpus spp.	tidepool shrimps	1	8	0.7			
Pandalus danae	dock shrimp				1	34	2.6
Pandalus spp.	unidentified shrimp	1	10	0.7			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				3	5 - 11	0.2 - 0.6

*Only one specimen was measured and weighed; the other could not be weighed nor measured because of mutilation.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0009	11/04/99	11/05/99	24	24	24	24	24	24	24	24

Table H1-10. Morro Bay Power Plant Impingement Abundance Survey 10, November 11, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	604	1500.0	1	125	10.3
Teleosts							
Atherinops affinis	topsmelt				2	67 - 68	2.10 - 2.9
Citharichthys sordidus	Pacific sanddab	1	-	-	1	86	10.6
Citharichthys stigmaeus	speckled sanddab				5	43 - 90	1.2 - 10.8
Hexagrammos decagrammus	kelp greenling				1	156	65.4
Ophiodon elongatus	lingcod				1	153	27.0
Porichthys notatus	plainfin midshipmen	1	-	-			
Sardinops sagax	Pacific sardine	2	170 - 175	52.9 - 66.3	2	149 - 182	30.6 - 63.5
Scorpaenichthys marmoratus	cabezon				1	135	49.3
Sebastes carnatus	gopher rockfish	1	85	16.3	1	93	19.5
Sebastes chrysomelas	black and yellow rockfish	1	87	16.7			
Symphurus atricauda	California tonguefish	9	76 - 90	2.1 - 8.6	14	72 - 91	3.4 - 6.5
Syngnathus leptorhynchus	bay pipefish				1	25	-
Crabs							
Cancer antennarius	brown rock crab	5	31 - 100	12.0 - 210.3	5	30 - 64	6.8 - 52.6
Cancer gracilis	slender rock crab				1	13	0.7
Cancer jordani	hairy rock crab	4	15 - 56	1.0 - 39.6			
Cancer spp.	cancer crabs				5	7 - 19	0.2 - 1.9
Loxorhynchus crispatus	moss crab				3	7 - 13	0.7 - 2.5
Pachygrapsus crassipes	striped shore crab				1	14	1.3
Portunus xantusii	Xantus' swimming crab	2	60 - 62	20.5 - 33.6	11	44 - 68	9.8 - 34.8
Pugettia producta	northern kelp crab	2*	4 - 14	1.6	1	25	7.4
Pugettia richii	cryptic kelp crab				2	11 - 13	0.7 - 1.1
Shrimps							
Crangon franciscorum	Franciscan bay shrimp				1	12	2.2
Heptacarpus spp.	tidepool shrimps				1	5	0.8
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	10	0.6	1	17	2.8

*Both specimens were measured, but only one specimen was weighed.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0010	11/11/99	11/12/99	24	24	23	24	24	24	24	24

Table H1-11. Morro Bay Power Plant Impingement Abundance Survey 11, November 18, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	644	1378.3			
Teleosts							
Agonidae unid.	poachers	1	60	0.9			
Citharichthys sordidus	Pacific sanddab				1	85	8.1
Citharichthys stigmaeus	speckled sanddab				8	67 - 97	4.4 - 16.4
Engraulis mordax	northern anchovy				1	128	19.4
Hexagrammos decagrammus	kelp greenling				1	120	18.5
Leptocottus armatus	Pacific staghorn sculpin	1	58	3.9	1	122	22.2
Sardinops sagax	Pacific sardine				2	148 - 162	40.4 - 43.9
Scorpaenichthys marmoratus	cabezon				1	115	36.1
Symphurus atricauda	California tonguefish	7	78 - 94	3.4 - 6.1	17	69 - 95	2.9 - 8.2
Crabs							
Cancer antennarius	brown rock crab	1	47	18.4	2	13 - 34	0.8 - 8.6
Cancer jordani	hairy rock crab	1	19	2.4			
Cancer spp.	cancer crabs	1	6	3.0	8	9 - 17	0.3 - 1.3
Loxorhynchus crispatus	moss crab	1	12	1.3	3	11 - 19	1.3 - 5.4
Pachygrapsus crassipes	striped shore crab				2	8 - 13	0.4 - 1.4
Podochela hemphilli	Hemphill's kelp crab				1	6	0.5
Portunus xantusii	Xantus' swimming crab	1	55	19.7	8	49 - 66	12.2 - 35.5
Pugettia producta	northern kelp crab	1	12	1.0	4	10 - 17	0.7 - 2.3
Pugettia richii	cryptic kelp crab	1	12	1.1			
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	14	1.2
Penaeus californiensis	brown shrimp				1	63	53.3
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	3	18 - 26	2.5 - 6.9	3	9 - 14	0.2 - 0.9

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0011	11/18/99	11/19/99	0	0	24	23	24	24	24	24

Table H1-12. Morro Bay Power Plant Impingement Abundance Survey 12, November 23, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	444	254.0
Platyrhinoidis triseriata	thornback				1	110	11.5
Teleosts							
Atherinops affinis	topsmelt				1	56	6.0
Atherinopsis californiensis	jacksmelt				2	45 - 71	1.5 - 3.7
Aulorhynchus flavidus	tubesnout				1	87	1.1
Citharichthys stigmaeus	speckled sanddab				2	59 - 70	2.2 - 4.5
Cottidae unid.	sculpins				1	81	10.0
Gobiesox maeandricus	northern clingfish				1	45	1.1
Hexagrammos decagrammus	kelp greenling				1	140	49.4
Hyperprosopon anale	spotfin surfperch				1	58	4.4
Leptocottus armatus	Pacific staghorn sculpin	3	98 – 135	36.8 - 47.3	2*	18 - 53	2.4
Odontopyxis trispinosa	pygmy poacher				1	30	0.3
Phanerodon furcatus	white surfperch				1	125	-
Porichthys notatus	plainfin midshipmen				1	38	1.1
Sardinops sagax	Pacific sardine				2	180 - 181	63.8 – 66.2
Sebastes atrovirens (juv.)	kelp rockfish	2	82 - 89	14.0 - 17.0	3	82 - 96	7.4 – 16.3
Sebastes spp.	rockfishes				1	68	5.8
Symphurus atricauda	California tonguefish	2	77 - 86	3.0 - 3.0	4	78 - 80	4.7 – 4.8
Syngnathus californiensis	kelp pipefish	2	107 – 194	0.2 - 4.2	7	69 - 225	0.4 – 6.2
Syngnathus leptorhynchus	bay pipefish				1	222	5.3
Ulvicola sanctaerosae	kelp gunnel				1	95	1.7
Crabs							
Cancer jordani	hairy rock crab	9	24 - 54	2.9 - 34.6	14	12 - 55	0.5 – 30.4
Cancer productus	red rock crab	1	22	1.8	3	20 - 52	1.5 – 19.3
Cancer spp.	cancer crabs				12	9 - 25	0.1 – 3.2
Loxorhynchus crispatus	moss crab	2	11 - 12	1.4 - 2.0			
Pachygrapsus crassipes	striped shore crab				1	16	1.8
Portunus xantusii	Xantus' swimming crab	1	64	28.5	18	45 - 71	10.4 – 52.0
Pugettia producta	northern kelp crab	2	11 - 20	1.5 - 4.5	10	10 - 26	0.3 – 7.9
Pugettia richii	cryptic kelp crab				4	9 - 11	0.1 – 1.1
Pugettia spp.	kelp crabs				2	7 - 11	0.8 – 1.8
Shrimps							
Heptacarpus spp.	tidepool shrimps	1	12	3.5			
Penaeus californiensis	brown shrimp				5	54 - 207	37.6 – 77.9
Cephalopods							
Loligo opalescens	market squid				1	144	13.3
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				6	7 - 38	0.5 – 16.1

*Both specimens were measured, but only one specimen was weighed.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0012	11/23/99	11/24/99	0	0	24	24	24	24	24	24

Table H1-13. Morro Bay Power Plant Impingement Abundance Survey 13, December 2, 1999.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	435	286.0
Teleosts							
Artedius lateralis	smoothhead sculpin				1	64	-
Citharichthys stigmaeus	speckled sanddab				2	45	0.8 - 1.1
Cottidae unid.	sculpins				1	124	36.5
Leptocottus armatus	Pacific staghorn sculpin				2	65 - 91	4.8 - 10.7
Scorpaenichthys marmoratus	cabezon				1	171	115.2
Sebastes atrovirens	kelp rockfish				1	221	-
Sebastes chrysomelas	black and yellow rockfish				1	77	11.6
Sebastes spp.	rockfishes				3	90 - 98	16.0 - 18.5
Symphurus atricauda	California tonguefish				11	78 - 89	3.7 - 5.9
Xererpes fucorum	rockweed gunnel				1	195	24.7
Crabs							
Cancer antennarius	brown rock crab				1	31	7.4
Cancer jordani	hairy rock crab				8	6 - 24	0.2 - 4.1
Cancer productus	red rock crab				1	40	9.6
Pachygrapsus crassipes	striped shore crab				2	13 - 17	0.7 - 0.9
Portunus xantusii	Xantus' swimming crab				6	47 - 64	12.7 - 36.9
Pugettia producta	northern kelp crab				6	10 - 67	1.2 - 146.4
Pugettia richii	cryptic kelp crab				1	12	1.6
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	12	3.2
Crangon spp.	bay shrimp				4	11 - 58	1.7 - 2.2
Heptacarpus spp.	tidepool shrimps				1	12	0.5
Penaeus californiensis	brown shrimp				1	53	31.9
Cephalopods							
Octopus spp.	octopus				1	60	153.9

* Units 1 and 2 not sampled because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0013	12/02/99	12/03/99	0	0	0	0	24	24	24	24

Table H1-14. Morro Bay Power Plant Impingement Abundance Survey 14, December 9, 1999.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	465	287.0
Teleosts							
Citharichthys stigmaeus	speckled sanddab	1	75	5.0			
Embiotoca lateralis	striped surfperch				1	141	80.0
Leptocottus armatus	Pacific staghorn sculpin				1	113	21.6
Porichthys notatus	plainfin midshipmen				1	42	1.0
Scorpaenichthys marmoratus	cabezon				1	105	26.3
Sebastes atrovirens	kelp rockfish				2**	21 - 63	6.0
Sebastes rastrelliger	grass rockfish				1	105	32.8
Symphurus atricauda	California tonguefish				2	80 - 90	4.7 - 6.5
Syngnathus leptorhynchus	bay pipefish				3	174 - 240	3.0 - 10.1
Crabs							
Cancer antennarius	brown rock crab	2	35 - 72	9.2 - 67.7			
Cancer jordani	hairy rock crab	3	10 - 21	0.2 - 4.1	15	8 - 32	0.2 - 8.5
Cancer magister	Dungeness crab				3	11 - 40	0.9 - 10.4
Cancer productus	red rock crab				1	17	0.9
Cancer spp.	cancer crabs				5	9 - 25	0.3 - 2.2
Lophopanopeus spp.	black-clawed crabs				1	13	0.8
Loxorhynchus crispatus	moss crab	1	13	2.0			
Pachygrapsus crassipes	striped shore crab				1	36	27.9
Portunus xantusii	Xantus' swimming crab	2	53 - 67	16.6 - 37.1	13	47 - 72	11.3 - 40.5
Pugettia producta	northern kelp crab	2	18 - 57	3.6 - 73.3	2	4 - 21	0.7 - 4.3
Pugettia richii	cryptic kelp crab	3	6 - 16	0.3 - 1.9	2	9 - 11	0.6 - 1.3
Shrimps							
Crangon franciscorum	Franciscan bay shrimp				1	10	0.9
Crangon nigricauda	black-tailed bay shrimp				3	12 - 13	1.9 - 2.1

* N = 5, Cycle 6 not sampled. Heavy amounts of debris required continuous screen washing, so samples could not be collected.

**Both specimens were measured, but only one specimen was weighed.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0014	12/09/99	12/10/99	0	0	24	24	24	24	24	24

Table H1-15. Morro Bay Power Plant Impingement Abundance Survey 15, December 16, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Artedius lateralis	smoothhead sculpin				2	59 - 72	3.8 - 6.8
Artedius spp.	sculpins				1	64	5.9
Citharichthys stigmaeus	speckled sanddab				9	51 - 93	2.6 - 11.8
Damalichthys vacca	pile surfperch	1	240	336.6			
Gibbonsia metzi	striped kelpfish	2	112 - 130	14.7 - 20.4			
Leptocottus armatus	Pacific staghorn sculpin	1	105	19.6	2	102 - 110	18.7 - 21.2
Porichthys notatus	plainfin midshipmen				2	52 - 108	1.3 - 19.0
Scorpaena guttata	spotted scorpinfish				1	67	9.7
Symphurus atricauda	California tonguefish	4	74 - 85	4.1 - 5.6	17	55 - 113	2.0 - 10.6
Syngnathus leptorhynchus	bay pipefish				1	185	3.8
Crabs							
Cancer antennarius	brown rock crab	2	40 - 60	14.5 - 47.7			
Cancer antennarius/C. jordani	cancer crabs	2	28 - 32	4.8 - 12.5			
Cancer jordani	hairy rock crab				18	10 - 34	0.3 - 10.3
Loxorhynchus crispatus	moss crab				2	17 - 45	3.60 - 57.3
Pachygrapsus crassipes	striped shore crab				1	9	0.5
Portunus xantusii	Xantus' swimming crab	5	53 - 65	19.5 - 31.0	43	45 - 72	12.8 - 53.6
Pugettia producta	northern kelp crab	1	15	2.3	3	7 - 32	0.6 - 18.6
Pugettia richii	cryptic kelp crab				3	6 - 10	0.1 - 1.2
Shrimps							
Crangon franciscorum	Franciscan bay shrimp				1	12	1.4
Crangon nigricauda	black-tailed bay shrimp	2	11 - 13	1.9 - 2.7	8	7 - 12	0.3 - 3.0
Crangon nigromaculata	spotted bay shrimp				3	7 - 12	0.7 - 1.9
Crangon spp.	bay shrimp				1	6	0.7
Heptacarpus spp.	tidepool shrimps				7	7 - 12	1.0 - 3.1

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0015	12/16/99	12/17/99	0	0	24	24	24	24	24	24

Table H1-16. Morro Bay Power Plant Impingement Abundance Survey 16, December 22, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	530	239.5
Teleosts							
Citharichthys stigmaeus	speckled sanddab				2	52 - 80	2.0 - 8.5
Cottidae unid.	sculpins				1	79	13.4
Platichthys stellatus	starry flounder				1	34	1.8
Porichthys notatus	plainfin midshipmen				1	30	1.1
Scorpaenichthys marmoratus	cabezon				1	108	32.6
Symphurus atricauda	California tonguefish				5	70 - 86	3.4 - 7.2
Syngnathus leptorhynchus	bay pipefish				6	140 - 220	1.5 - 8.5
Syngnathus spp.	pipefishes				1	-	2.0
Crabs							
Cancer antennarius	brown rock crab				2	39 - 73	13.4 - 125.0
Cancer jordani	hairy rock crab	2	21 - 34	0.9 - 8.8	26	7 - 32	0.1 - 8.8
Cancer productus	red rock crab				1	8	1.4
Cancer spp.	cancer crabs				1	8	0.1
Loxorhynchus crispatus	moss crab	2	7 - 12	0.1 - 2.5	4	10 - 25	0.3 - 10.5
Pachygrapsus crassipes	striped shore crab				2	9 - 23	0.5 - 5.7
Portunus xantusii	Xantus' swimming crab	3	52 - 60	16.4 - 27.9	18	49 - 71	13.4 - 47.0
Pugettia producta	northern kelp crab	2	51 - 63	67.3 - 139.1	12	10 - 42	0.4 - 25.5
Pugettia richii	cryptic kelp crab	1	8	0.7	5	4 - 12	0.5 - 2.7
Pugettia spp.	kelp crabs				1	3	0.1
Shrimps							
Crangon franciscorum	Franciscan bay shrimp				1	7	1.9
Crangon nigricauda	black-tailed bay shrimp				1	9	0.2
Crangon nigromaculata	spotted bay shrimp				3	7 - 8	1.8 - 2.2
Crangon spp.	bay shrimp				1	12	2.1
Heptacarpus spp.	tidepool shrimps				2	7 - 10	0.5 - 0.9
Penaeus californiensis	brown shrimp	2	46 - 70	25.4 - 67.8	40	38 - 80	20.8 - 51.4
Cephalopods							
Octopus spp.	octopus				1	56	38.8
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				7	8 - 31	0.1 - 11.9

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0016	12/22/99	12/23/99	0	0	24	24	24	24	24	24

Table H1-17. Morro Bay Power Plant Impingement Abundance Survey 17, December 29, 1999.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Agonidae unid.	poachers				1	1	51.0
Citharichthys stigmaeus	speckled sanddab	1	93	10.7	3	61 - 72	3.3 - 5.8
Sebastes chrysomelas (juv.)					1	11	77.0
Symphurus atricauda	California tonguefish				2	73 - 84	3.7 - 5.9
Syngnathus leptorhynchus	bay pipefish				1	162	3.1
Crabs							
Cancer antennarius	brown rock crab	2	18 - 33	2.5 - 9.0	2	36 - 40	10.1 - 15.6
Cancer antennarius/C. jordani	cancer crabs	3	18 - 34	1.7 - 10.9	2	33 - 35	6.2 - 7.6
Cancer jordani	hairy rock crab	1	21	2.4	7	9 - 35	0.6 - 10.4
Cancer productus	red rock crab				2	12 - 46	0.7 - 13.0
Cancer spp.	cancer crabs	1	12	0.7	9	6 - 12	0.2 - 1.2
Loxorhynchus crispatus	moss crab				2	7 - 12	0.6 - 1.5
Portunus xantusii	Xantus' swimming crab	2	44 - 55	10.5 - 18.8	16	45 - 67	10.0 - 41.3
Pugettia producta	northern kelp crab				1	19	2.3
Pugettia richii	cryptic kelp crab				1	15	2.1
Scyra acutifrons	sharp-nosed crab	2	15	2.6 - 3.2			
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				6	9 - 13	0.7 - 2.6
Crangon nigromaculata	spotted bay shrimp				3	10 - 14	1.5 - 2.2
Heptacarpus spp.	tidepool shrimps				2	6 - 9	0.7 - 1.1
Penaeus californiensis	brown shrimp				4	51 - 57	26.8 - 37.9

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0017	12/29/99	12/30/99	0	0	24	24	24	24	24	24

Table H1-18. Morro Bay Power Plant Impingement Abundance Survey 18, January 6, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Citharichthys stigmaeus	speckled sanddab	1	75	4.3	2	42 - 94	1.3 - 9.7
Gibbonsia montereyensis	crevice kelpfish				1	80	6.4
Leptocottus armatus	Pacific staghorn sculpin	1	78	7.9			
Oligocottus snyderi	fluffy sculpin				1	55	3.5
Porichthys notatus	plainfin midshipmen				1	40	0.5
Sardinops sagax	Pacific sardine				1	238	81.5
Scorpaenichthys marmoratus	cabezon	1	190	105.5	1	134	53.0
Sebastes rastrelliger	grass rockfish				2	11 - 110	21.1 - 21.5
Symphurus atricauda	California tonguefish	1	83	4.5	3	70 - 87	3.1 - 6.5
Syngnathus leptorhynchus	bay pipefish				2	165 - 250	3.4 - 5.4
Crabs							
Cancer antennarius	brown rock crab	4	62 - 80	48.7 - 100.3			
Cancer jordani	hairy rock crab	9	18 - 66	2.1 - 65.2	9	8 - 42	0.4 - 15.4
Cancer magister	Dungeness crab				1	12	1.5
Cancer productus	red rock crab				1	13	7.0
Cancer spp.	cancer crabs				2	11 - 19	0.5 - 1.3
Heterocrypta occidentalis	elbow crab				1	26	3.8
Loxorhynchus crispatus	moss crab				1	11	0.9
Pachycheles spp.	porcelain crabs				1	16	2.9
Pachygrapsus crassipes	striped shore crab				2	16 - 19	1.8 - 3.2
Portunus xantusii	Xantus' swimming crab	2	55 - 57	24.1 - 24.8	5	52 - 65	12.4 - 36.5
Pugettia producta	northern kelp crab	3	11 - 15	1.0 - 2.0	4	7 - 50	0.4 - 56.0
Pugettia richii	cryptic kelp crab	1	14	1.6	1	8	0.4
Scyra acutifrons	sharp-nosed crab	1	15	2.7	2	12 - 19	1.0 - 6.7
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				3	11 - 12	0.7 - 4.30
Crangon nigromaculata	spotted bay shrimp				2	9 - 9	2.8 - 3.0
Crangon spp.	bay shrimp	1	11	1.7	1	10	3.2
Heptacarpus spp.	tidepool shrimps				2	7 - 9	0.4 - 1.1
Penaeus californiensis	brown shrimp	3	34 - 36	19.0 - 33.0	10	31 - 57	19.9 - 43.0
Cephalopods							
Octopus spp.	octopus				1	33	11.6
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	13	1.6	1	13	1.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0018	01/06/00	01/07/00	8	8	24	24	24	24	24	24

Table H1-19. Morro Bay Power Plant Impingement Abundance Survey 19, January 13, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Citharichthys sordidus	Pacific sanddab	1	54	2.7			
Citharichthys stigmaeus	speckled sanddab				1	33	0.5
Engraulis mordax	northern anchovy				12*	91 - 105	2.5
Scorpaenichthys marmoratus	cabezon	1	110	34.6	1	125	56.0
Symphurus atricauda	California tonguefish				3	75 - 77	4.5 - 5.0
Crabs							
Cancer antennarius	brown rock crab	2	67 - 75	45.6 - 81.6	1	77	71.0
Cancer antennarius/C. jordani	cancer crabs				1	32	8.6
Cancer jordani	hairy rock crab	3	11 - 54	0.5 - 36.6	13	8 - 29	0.1 - 7.5
Cancer productus	red rock crab				1	12	0.1
Cancer spp.	cancer crabs	1	13	0.4	4	5 - 11	0.1 - 0.4
Loxorhynchus crispatus	moss crab				3	7 - 19	1.0 - 8.5
Portunus xantusii	Xantus' swimming crab	19	47 - 62	6.7 - 32.0	27	48 - 68	13.5 - 42.7
Pugettia producta	northern kelp crab				2	15 - 15	1.6 - 3.3
Pugettia richii	cryptic kelp crab	1	10	1.4	1	9	1.7
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	4	7 - 11	0.5 - 2.1	9	6 - 12	0.1 - 3.0
Crangon nigromaculata	spotted bay shrimp	2	7 - 8	1.2 - 1.3	4	9 - 14	1.7 - 3.2
Heptacarpus spp.	tidepool shrimps				1	7	1.1
Penaeus californiensis	brown shrimp	1	48	22.4	7	44 - 59	19.5 - 40.3
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	19 - 22	2.8 - 4.4			

*All twelve were mutilated. Length measurements were made from two specimens, and a weight was taken from one specimen.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0019	01/13/99	01/14/99	24	24	24	24	24	24	24	24

Table H1-20. Morro Bay Power Plant Impingement Abundance Survey 20, January 20, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt				1	119	-
Odontopyxis trispinosa	pygmy poacher	1	88	2.6			
Symphurus atricauda	California tonguefish				1	86	5.0
Syngnathus leptorhynchus	bay pipefish	1	228	11.2			
Xiphister mucosus	rock prickleback				1	114	84.0
Crabs							
Cancer antennarius	brown rock crab	2	26 - 66	3.7 - 69.2			
Cancer jordani	hairy rock crab	2	20 - 74	1.8 - 79.5	9	11 - 31	0.4 - 7.8
Cancer productus	red rock crab	1	137	345.0			
Cancer spp.	cancer crabs	3	9 - 16	0.3 - 0.8	7	6 - 21	0.1 - 2.2
Loxorhynchus crispatus	moss crab	1	12	0.8			
Majidae	spider crabs	1	-	-			
Pachycheles pubescens	pubescent porcelain crab				1	11	1.8
Pelia tumida	dwarf crab	1	13	0.6			
Portunus xantusii	Xantus' swimming crab	3	50 - 62	13.3 - 32.0	7	53 - 69	19.8 - 34.0
Pugettia producta	northern kelp crab	1	8	0.8	6	6 - 43	0.2 - 30.4
Pugettia richii	cryptic kelp crab				1	6	1.0
Pugettia spp.	kelp crabs				2	0.4 - 17	0.5 - 3.1
Pyromaia tuberculata	majidae crab				1	10	1.6
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	3	8 - 13	0.6 - 3.6	2	11 - 13	1.3 - 3.9
Crangon spp.	bay shrimp	1	14	3.9			
Heptacarpus spp.	tidepool shrimps				1	8	2.9
Pandalus danae	dock shrimp				1	38	6.2
Penaeus californiensis	brown shrimp	10	32 - 49	20.0 - 40.0	35	30 - 59	19.3 - 49.7
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	28	8.6	1	10	0.4

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0020	01/20/00	01/21/00	24	24	24	24	24	24	24	24

Table H1-21. Morro Bay Power Plant Impingement Abundance Survey 21, January 27, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Scorpaenichthys marmoratus	cabezon	1	139	67.0			
Symphurus atricauda	California tonguefish				2	80 - 82	5.1 - 5.8
Syngnathus leptorhynchus	bay pipefish	1	212	4.8			
Syngnathus spp.	pipefishes	1	-	-			
Crabs							
Cancer antennarius	brown rock crab	1	38	11.5			
Cancer antennarius/C. jordani	cancer crabs				1	39	11.0
Cancer jordani	hairy rock crab	3	18 - 52	2.7 - 30.6	12	12 - 36	0.4 - 9.7
Cancer productus	red rock crab				2	32	6.0
Cancer spp.	cancer crabs	1	77	-	4	8 - 17	0.1 - 2.0
Pachygrapsus crassipes	striped shore crab				1	29	13.1
Portunus xantusii	Xantus' swimming crab	5	55 - 59	18.9 - 28.7	7	42 - 63	13.0 - 33.6
Pugettia producta	northern kelp crab				3	9 - 27	0.5 - 8.1
Pugettia richii	cryptic kelp crab				4	1 - 5	0.1 - 1.4
Shrimps							
Alpheus clamator	twistclaw pistol shrimp				2	9 - 10	2.9 - 3.1
Crangon nigromaculata	spotted bay shrimp	1	11	5.1	4	9 - 12	1.0 - 1.9
Penaeus californiensis	brown shrimp	2	32 - 47	22.2 - 22.6	13	30 - 55	19.1 - 65.2

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0021	01/27/00	01/28/00	24	24	24	24	24	24	24	24

Table H1-22. Morro Bay Power Plant Impingement Abundance Survey 22, February 3, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Artedius lateralis	smoothhead sculpin	1	67	7.3			
Atherinops affinis	topsmelt	1	56	2.1			
Citharichthys stigmaeus	speckled sanddab	1	53	1.2	2	46 - 48	1.5
Gobiesox maeandricus	northern clingfish				1	54	1.7
Scorpaenichthys marmoratus	cabezon	1	142	75.1			
Crabs							
Cancer antennarius	brown rock crab	2	23 - 28	3.6 - 6.9	2	21 - 22	2.0 - 3.1
Cancer anthonyi	yellow rock crab				1	66	52.7
Cancer gracilis	slender rock crab	1	24	2.9			
Cancer jordani	hairy rock crab	3	12 - 15	1.4 - 3.3	13	12 - 29	0.5 - 7.1
Cancer productus	red rock crab				1	13	0.8
Cancer spp.	cancer crabs	2	11 - 21	0.2 - 3.3	9	7 - 14	0.1 - 0.8
Loxorhynchus crispatus	moss crab				1	5	0.3
Pachycheles spp.	porcelain crabs				1	5	0.2
Pachygrapsus crassipes	striped shore crab				2	9 - 22	0.2 - 5.2
Portunus xantusii	Xantus' swimming crab	7	50 - 63	13.0 - 32.0	10	50 - 70	14.3 - 43.7
Pugettia producta	northern kelp crab	2	15 - 23	4.3 - 5.3	5	5 - 20	0.1 - 7.0
Pugettia richii	cryptic kelp crab				1	11	1.0
Shrimps							
Alpheus clamator	twistclaw pistol shrimp				2	9 - 10	0.8 - 2.4
Crangon nigricauda	black-tailed bay shrimp	6	6 - 13	0.2 - 3.1	5	8 - 12	0.6 - 1.7
Crangon nigromaculata	spotted bay shrimp	1	8	-	2	9 - 10	1.3
Pandalus spp.	unidentified shrimp				1	10	1.0
Penaeus californiensis	brown shrimp	1	55	38.0	5	32 - 55	19.2 - 40.0
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	4	10 - 28	1.0 - 12.3	1	9	3.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0022	02/03/00	02/04/00	24	24	24	24	24	24	24	24

Table H1-23. Morro Bay Power Plant Impingement Abundance Survey 23, February 10, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Artedius spp.	sculpins				1	118	36.8
Atherinopsis californiensis	jacksmelt	1	294	-			
Citharichthys stigmaeus	speckled sanddab	1	45	1.4	5	40 - 50	1.2 - 1.9
Porichthys notatus	plainfin midshipmen				1	54	2.0
Scorpaenichthys marmoratus	cabezon	1	102	-			
Stichaeidae unid.	pricklebacks				1	79	9.5
Symphurus atricauda	California tonguefish	1	88	7.1			
Crabs							
Cancer antennarius	brown rock crab	1	54	32.2	4	11 - 31	0.2 - 7.5
Cancer anthonyi	yellow rock crab				1	50	14.7
Cancer jordani	hairy rock crab	1	24	3.0	5	13 - 30	0.8 - 5.8
Cancer productus	red rock crab	1	66	37.2			
Cancer spp.	cancer crabs	1	30	4.8	16	8 - 21	0.2 - 1.6
Pachygrapsus crassipes	striped shore crab				3	8 - 22	0.2 - 6.5
Portunus xantusii	Xantus' swimming crab	7	48 - 67	9.6 - 43.4	4	61 - 68	27.1 - 40.6
Pugettia producta	northern kelp crab				6	8 - 25	0.2 - 6.6
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	6	10 - 13	0.8 - 8.2	2	11 - 15	1.4 - 3.4
Crangon nigromaculata	spotted bay shrimp				3	9 - 12	0.7 - 1.4
Heptacarpus spp.	tidepool shrimps				3	5 - 10	0.1 - 0.8
Penaeus californiensis	brown shrimp	4	45 - 60	20.4 - 32.0	6	33 - 67	16.4 - 56.8
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	16 - 30	1.6 - 11.4	2	13 - 21	1.1 - 4.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0023	02/10/00	02/11/00	24	24	24	24	24	24	24	24

Table H1-24. Morro Bay Power Plant Impingement Abundance Survey 24, February 17, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt	1	115	6.8			
Citharichthys sordidus	Pacific sanddab	1	85	3.7	1	50	1.8
Damalichthys vacca	pile surfperch	1	310	784.1	1	122	24.5
Leptocottus armatus	Pacific staghorn sculpin	1	87	15.0			
Ophidion scrippsae	basketweave cusk-eel	1	225	61.5	1	124	10.8
Sardinops sagax	Pacific sardine	1	174	68.4			
Stichaeidae unid.	pricklebacks	1*	-	-	2**	153	20.20
Crabs							
Cancer antennarius	brown rock crab	2	33 - 74	9.8 - 61.2	1	22	3.0
Cancer gracilis	slender rock crab				1	12	0.6
Cancer jordani	hairy rock crab	5	15 - 29	2.0 - 8.4	18	10 - 27	0.8 - 3.6
Cancer productus	red rock crab	1	97	138.0			
Cancer spp.	cancer crabs	3	9 - 11	0.4 - 1.4	15	5 - 18	0.1 - 1.7
Emerita analoga	mole crab				1	16	3.3
Loxorhynchus spp.	spider crabs				3	6 - 19	0.1 - 3.6
Portunus xantusii	Xantus' swimming crab	18	45 - 65	11.8 - 42.2	30	42 - 80	10.3 - 48.6
Pugettia producta	northern kelp crab	2	8 - 50	1.0 - 56.3	3	8 - 26	0.4 - 8.9
Pugettia richii	cryptic kelp crab				2	7 - 8	0.2 - 0.5
Shrimps							
Alpheus spp.	pistol shrimp	1	12	1.6			
Crangon nigricauda	black-tailed bay shrimp	1	8	1.1	1	9	1.3
Heptacarpus spp.	tidepool shrimps				2	8 - 11	0.9 - 1.8
Penaeus californiensis	brown shrimp				2	30 - 33	23.4 - 26.1
Cephalopods							
Loligo opalescens	market squid	2	59 - 65	6.5 - 7.7			
Octopus spp.	octopus	1	60	41.0			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	25	4.2 - 4.9			

*One specimen was mutilated, and not measured nor weighed.

**Two specimens were collected. One specimen was mutilated and not measured nor weighed.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0024	02/17/00	02/18/00	24	24	24	24	24	24	24	24

Table H1-25. Morro Bay Power Plant Impingement Abundance Survey 25, February 24, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray	1	480	291.7	2	180 - 410	298.0 - 332.5
Teleosts							
Anoplarchus purpurescens	high cockscomb				1	14	8.0
Artedius lateralis	smoothhead sculpin				2	60 - 67	5.0 - 6.3
Artedius spp.	sculpins				6	67 - 89	4.4 - 14.8
Atherinops affinis	topsmelt	68	11 - 189	20.7 - 62.5	568	90 - 220	4.5 - 81.6
Chilara taylori	spotted cusk-eel	3	126 - 150	12.0 - 58.1	3	121 - 158	8.5 - 25.9
Citharichthys stigmaeus	speckled sanddab	1	80	4.2	20	44 - 95	0.5 - 9.0
Embiotoca lateralis	striped surfperch				1	154	116.7
Gibbonsia montereyensis	crevice kelpfish				1	105	13.3
Gobiesox maeandricus	northern clingfish				1	50	4.5
Hyperprosopon argenteum	walleye surfperch				1	135	59.4
Hypsoblennius jenkinsi	mussel blenny	1	50	4.6			
Leptocottus armatus	Pacific staghorn sculpin	2	115 - 123	23.4 - 25.1	7	9 - 122	0.6 - 28.5
Microstomus pacificus	Dover sole	1	6	2.3	5	43 - 54	2.0 - 4.0
Ophidion scrippsae	basketweave cusk-eel	7	15 - 195	11.0 - 44.3	19	115 - 162	9.0 - 22.0
Osmeridae unid.	smelts				1	105	5.0
Parophrys vetulus	English sole				1	44	1.2
Pleuronichthys decurrens	curlfin turbot				1	129	62.0
Scorpaenichthys marmoratus	cabezon				3	53 - 133	4.0 - 62.0
Sebastes rastrelliger	grass rockfish				2	90 - 110	14.3 - 24.2
Syngnathus leptorhynchus	bay pipefish				1	222	17.0
Crabs							
Cancer antennarius	brown rock crab	1	73	74.8	2	31 - 144	7.4 - 29.8
Cancer antennarius/C. jordani	cancer crabs				2	12 - 15	0.3- 1.6
Cancer jordani	hairy rock crab	4	19 - 28	1.9 - 3.7	17	12 - 33	0.2 - 10.2
Cancer magister	Dungeness crab				1	23	5.5
Cancer productus	red rock crab				1	100	105.7
Cancer spp.	cancer crabs	1	51	9.5	4	11 - 27	0.1 - 6.0
Loxorhynchus crispatus	moss crab				16	9 - 22	0.4 - 8.3
Loxorhynchus spp.	spider crabs	1	10	2.5	1	11	3.9
Pachycheles pubescens	pubescent porcelain crab				7	9-18	0.7-6.4
Pelia tumida	dwarf crab				3	7 - 14	2.5 - 4.3
Podochela hemphilli	Hemphill's kelp crab	1	9	1.3			
Portunus xantusii	Xantus' swimming crab	13	42 - 58	12.9 - 26.8	38	46 - 73	12.1 - 51.0
Pugettia producta	northern kelp crab	1	12	0.7	2	7 - 20	2.5 - 6.5
Pugettia richii	cryptic kelp crab	1	16	3.5	2	12 - 13	0.6 - 0.8
Scyra acutifrons	sharp-nosed crab	1	17	4.1			
Shrimps							
Alpheus clamator	twistclaw pistol shrimp				3	9 - 11	0.3 - 1.2
Crangon nigricauda	black-tailed bay shrimp	19	8 - 17	2.0 - 5.4	130	7 - 90	0.5 - 15.0
Crangon nigromaculata	spotted bay shrimp	5	10 - 18	1.1 - 2.3	54	1 - 12	0.4 - 5.1
Crangon spp.	bay shrimp				8	8 - 14	0.6 - 3.1
Heptacarpus spp.	tidepool shrimps	2	5 - 10	0.5 - 1.5	8	7 - 15	0.5 - 1.7
Pandalus spp.	unidentified shrimp				1	8	0.4
Penaeus californiensis	brown shrimp				2*	50 - 55	64.5
Spirontocaris spp.	broken-back shrimp				3	7 - 9	0.5 - 3.5
Cephalopods							
Octopus spp.	octopus	12	40 - 55	25.5 - 37.2	25	40 - 120	15.8 – 290.0
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	5	12 - 35	1.4 - 17.0			

*Both specimens were measured for length, but only one could be weighed.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0025	02/24/00	02/25/00	24	24	0	0	24	24	24	24

Table H1-26. Morro Bay Power Plant Impingement Abundance Survey 26, March 2, 2000.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				2	280 - 282	324.0 - 372.0
Teleosts							
Atherinops affinis	topsmelt				1	160	25.6
Aulorhynchus flavidus	tubesnout				1	90	3.3
Citharichthys stigmaeus	speckled sanddab				1	42	0.9
Engraulis mordax	northern anchovy				2	38 - 45	
Ophidion scrippsae	basketweave cusk-eel				1	175	31.0
Spirinchus starksi	night smelt				1	110	7.4
Crabs							
Cancer antennarius	brown rock crab				2	19 - 38	1.9 - 12.3
Cancer jordani	hairy rock crab				9	10 - 27	0.4 - 4.8
Cancer magister	Dungeness crab				2	14 - 15	1.4 - 1.8
Cancer spp.	cancer crabs				6	10 - 18	0.1 - 1.5
Pachycheles rudis	porcelain crabs				1	14	2.3
Pachygrapsus crassipes	striped shore crab				4	4 - 15	0.4 - 1.4
Portunus xantusii	Xantus' swimming crab				12	50 - 56	13.9 - 24.5
Pugettia producta	northern kelp crab				2	6 - 18	0.2 - 3.2
Pugettia richii	cryptic kelp crab				4	3 - 11	0.1 - 1.8
Pugettia spp.	kelp crabs				1	21	5.4
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				3	10 - 14	1.0 - 3.5
Crangon nigromaculata	spotted bay shrimp				4	8 - 12	0.5 - 1.6
Heptacarpus spp.	tidepool shrimps				1	8	-
Penaeus californiensis	brown shrimp				1	47	51.2
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				5	10 - 57	0.7 - 57.8

* Units 1 and 2 not sampled because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0026	03/02/00	03/03/00	0	0	0	0	24	24	24	24

Table H1-27. Morro Bay Power Plant Impingement Abundance Survey 27, March 9, 2000.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt				2	70 - 71	2.6 - 2.9
Aulorhynchus flavidus	tubesnout				1	73	0.1
Engraulis mordax	northern anchovy				1	31	-
Hexagrammos decagrammus	kelp greenling				1	137	46.2
Sebastes atrovirens	kelp rockfish				1	92	22.0
Symphurus atricauda	California tonguefish				1	-	-
Crabs							
Cancer antennarius	brown rock crab				5	28 - 53	4.1 - 19.8
Cancer antennarius/C. jordani	cancer crabs				1	18	0.8
Cancer jordani	hairy rock crab				4	9 - 18	0.5 - 1.5
Cancer productus	red rock crab				1	66	45.7
Cancer spp.	cancer crabs				3	9 - 21	0.1 - 2.2
Loxorhynchus crispatus	moss crab				1	10	0.5
Pachygrapsus crassipes	striped shore crab				1	14	1.3
Portunus xantusii	Xantus' swimming crab				3	54 - 57	17.0 - 19.4
Pugettia producta	northern kelp crab				7	8 - 44	0.4 - 52.8
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				11	8 - 14	0.2 - 2.1
Crangon nigromaculata	spotted bay shrimp				16	9 - 14	0.1 - 2.1
Penaeus californiensis	brown shrimp				2	47 - 50	20.3 - 25.7
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				2	16 - 27	1.8

* Units 1 and 2 not sampled because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0027	03/09/00	03/10/00	0	0	3	3	24	24	24	24

Table H1-28. Morro Bay Power Plant Impingement Abundance Survey 28, March 16, 2000.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Crabs							
Cancer antennarius	brown rock crab				2	27 - 47	4.1 - 19.0
Cancer spp.	cancer crabs				4	16 - 22	1.1 - 2.5
Loxorhynchus crispatus	moss crab				1	14	2.3
Pachygrapsus crassipes	striped shore crab				1	14	1.2
Pugettia producta	northern kelp crab				2	6 - 22	0.3 - 2.8
Pugettia richii	cryptic kelp crab				3	6 - 9	0.1 - 0.5

* Units 1 and 2 not sampled because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0028	03/16/00	03/17/00	0	0	0	0	24	24	0	0

Table H1-29. Morro Bay Power Plant Impingement Abundance Survey 29, March 20, 2000.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Aulorhynchus flavidus	tubesnout				1	140	5.5
Echeneis naucrates	sharksucker				1	432	463.1
Embiotoca jacksoni	black surfperch				3	165 - 230	143.0 - 405.0
Embiotoca lateralis	striped surfperch				1	150	105.0
Porichthys notatus	plainfin midshipmen				1	170	31.6
Spirinchus starksi	night smelt				1	108	11.7
Crabs							
Cancer antennarius	brown rock crab				3	28 - 92	4.8 - 123.3
Cancer anthonyi	yellow rock crab				1	94	63.4
Cancer jordani	hairy rock crab				13	6 - 32	0.3 - 7.3
Cancer productus	red rock crab				1	9	1.2
Cancer spp.	cancer crabs				9	8 - 17	0.9 - 2.4
Loxorhynchus crispatus	moss crab				1	8	1.3
Pachygrapsus crassipes	striped shore crab				3	13 - 37	2.0 - 19.3
Portunus xantusii	Xantus' swimming crab				3	55 - 64	23.6 - 28.3
Pugettia producta	northern kelp crab				11	7 - 67	0.5 - 137.8
Pugettia richii	cryptic kelp crab				4	6 - 16	0.5 - 2.7
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				6	9 - 10	1.2 - 1.9
Crangon nigromaculata	spotted bay shrimp				1	10	1.6
Crangon spp.	bay shrimp				1	-	-
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				2	31 - 35	14.0 - 17.0

* Units 1 and 2 not sampled because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0029	03/20/00	03/21/00	0	0	0	0	24	24	24	24

Table H1-30. Morro Bay Power Plant Impingement Abundance Survey 30, March 30, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Artedius spp.	sculpins				1	52	2.5
Aulorhynchus flavidus	tubesnout				1	109	1.0
Citharichthys stigmaeus	speckled sanddab				3	41 - 55	0.4 - 1.4
Embiotoca jacksoni	black surfperch				1	110	50.2
Crabs							
Cancer antennarius	brown rock crab	5	12 - 52	1.4 - 33.9	2	18	2.2 - 3.3
Cancer antennarius/C. jordani	cancer crabs				2	14 - 25	0.9 - 4.5
Cancer jordani	hairy rock crab				5	9 - 17	0.3 - 1.6
Cancer spp.	cancer crabs				7	3 - 20	0.1 - 1.5
Pugettia gracilis	graceful kelp crab				1	11	0.5
Pugettia producta	northern kelp crab				4	6 - 11	0.3 - 1.0
Pugettia richii	cryptic kelp crab				4	6 - 15	0.3 - 1.6
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	11	1.1
Hippolytidae unid.	Hippolytid shrimps				1	6	0.6
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	13 - 24	2.8 - 5.3			

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0030	03/30/00	03/31/00	0	0	21	5	24	24	24	24

Table H1-31. Morro Bay Power Plant Impingement Abundance Survey 31, April 6, 2000.

		Units 1 and 2			Units 3 and 4*		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt				1	137	23.1
Citharichthys sordidus	Pacific sanddab	1	55	2.3	1	15	1.3
Citharichthys stigmaeus	speckled sanddab	2	30 - 50	0.3 - 1.6	2	45 - 54	1.3 - 2.9
Cymatogaster aggregata	shiner surfperch				1	81	10.7
Embiotoca jacksoni	black surfperch				1	204	264.3
Leptocottus armatus	Pacific staghorn sculpin				2	59 - 62	0.9 - 2.7
Phytichthys chirus	ribbon prickleback				1	170	14.5
Psettichthys melanostictus	sand sole	1	46	1.6			
Sebastes atrovirens	kelp rockfish				1	79	12.7
Crabs							
Cancer antennarius	brown rock crab	2	21 - 56	2.3 - 33.2	29	8 - 44	0.3 - 19.8
Cancer antennarius/C. jordani	cancer crabs	2	16 - 30	0.4 - 5.8	2	11 - 21	0.3 - 2.1
Cancer anthonyi	yellow rock crab				1	22	1.7
Cancer jordani	hairy rock crab	2	17 - 25	1.2 - 3.2	10	9 - 22	0.5 - 2.5
Cancer spp.	cancer crabs	1	17	2.6	7	11 - 24	0.5 - 2.3
Lophopanopeus spp.	black-clawed crabs				1	20	3.2
Loxorhynchus crispatus	moss crab				7	6 - 14	0.3 - 1.9
Mimulus foliatus		1	16	1.5			
Pachygrapsus crassipes	striped shore crab				3	7 - 17	1.0 - 2.2
Pugettia producta	northern kelp crab				9	4 - 23	0.3 - 1.3
Pugettia richii	cryptic kelp crab				3	5 - 10	0.2 - 0.9
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	3	11 - 13	1.1 - 1.4	11	8 - 13	0.9 - 3.8
Crangon nigromaculata	spotted bay shrimp				3	9 - 13	1.2 - 1.6
Heptacarpus spp.	tidepool shrimps	1	10	2.1	2	7 - 11	0.4 - 1.7
Palaemon macrodactylus	oriental shrimp				2	7 - 8	0.2 - 0.7
Cephalopods							
Loligo opalescens	market squid				2	50 - 52	4.0 - 4.4

* N = 5, Cycle 6 not sampled due to heat treatment work at the intake.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0031	04/06/00	04/07/00	24	24	22	21	24	24	24	24

Table H1-32. Morro Bay Power Plant Impingement Abundance Survey 32, April 14, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Citharichthys sordidus	Pacific sanddab				1	65	2.8
Crabs							
Cancer antennarius	brown rock crab	1	33	8.9	2	23 - 24	3.3 - 3.6
Cancer jordani	hairy rock crab				1	22	2.9
Cancer spp.	cancer crabs				6	6 - 13	0.2 - 2.6
Pugettia producta	northern kelp crab				7	8 - 52	0.3 - 66.4
Pugettia richii	cryptic kelp crab				3	4 - 6	0.1 - 2.0
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	1	7.0	2.4	3	9 - 12	3.0 - 4.3

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0032	04/14/00	04/15/00	9	9	9	9	24	24	0	0

Table H1-33. Morro Bay Power Plant Impingement Abundance Survey 33, April 20, 2000.

		Units 1 and 2*			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Crabs							
Cancer antennarius	brown rock crab	3	18 - 58	1.4 - 38.6			
Cancer jordani	hairy rock crab				4	12 - 22	0.4 - 3.8
Cancer spp.	cancer crabs				2	5 - 14	0.1 - 0.5
Loxorhynchus crispatus	moss crab				1	9	0.4
Pachygrapsus crassipes	striped shore crab				1	20	5.5
Pugettia producta	northern kelp crab				3	4 - 9	0.1 - 0.4
Pugettia richii	cryptic kelp crab				1	3	0.1
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				3	14 - 24	1.4 - 7.5

* N = 2, Cycles 1-4 not collected because pumps were not operating.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0033	04/20/00	04/21/00	0	0	4	4	0	24	0	0

Table H1-34. Morro Bay Power Plant Impingement Abundance Survey 34, April 27, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt	1	140	27.6			
Citharichthys stigmaeus	speckled sanddab	1	50	0.6			
Sebastes rastrelliger	grass rockfish	1	200	142.3			
Crabs							
Cancer antennarius	brown rock crab				4	22 - 32	2.5 - 9.0
Cancer jordani	hairy rock crab	2	17 - 20	1.2 - 2.0	8	2 - 34	0.1 - 9.2
Cancer spp.	cancer crabs				2	11 - 15	0.5 - 1.0
Loxorhynchus crispatus	moss crab				1	14	2.1
Pachygrapsus crassipes	striped shore crab				1	6	0.1
Pugettia producta	northern kelp crab	1	16	1.9	2	8 - 11	0.3 - 0.7
Pugettia richii	cryptic kelp crab				6	2 - 8	0.1 - 0.3
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	4	9 - 14	0.4 - 1.1			
Heptacarpus spp.	tidepool shrimps				1	62	0.2
Cephalopods							
Octopus spp.	octopus	1	-	-			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	12	0.5	1	44	31.8

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0034	04/27/00	04/28/00	0	0	24	23	0	24	0	0

Table H1-35. Morro Bay Power Plant Impingement Abundance Survey 35, May 4, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt	1	166	32.0			
Citharichthys sordidus	Pacific sanddab	9	42 - 99	1.1 - 11.7	2	65 - 72	4.1 - 4.3
Citharichthys stigmaeus	speckled sanddab	12	29 - 90	0.2 - 11.4			
Embiotoca lateralis	striped surfperch				1	290	438.0
Genyonemus lineatus	white croaker	1	42	1.3			
Leptocottus armatus	Pacific staghorn sculpin	2	65 - 80	5.1 - 7.4	1	50	2.0
Pholididae unid.	gunnels				1	180	15.2
Porichthys notatus	plainfin midshipmen				2	175 - 260	51.4 - 179.8
Scorpaenichthys marmoratus	cabezon				2	172 - 174	122.7 - 130.7
Sebastes rastrelliger	grass rockfish				1	240	215.5
Syngnathus spp.	pipefishes				1	170	3.3
Crabs							
Cancer antennarius	brown rock crab	3	23 - 43	5.9 - 25.5	3	21 - 38	4.8 - 14.5
Cancer antennarius/C. jordani	cancer crabs				3	8 - 12	0.1 - 0.5
Cancer gracilis	slender rock crab	1	18	3.3	3	9 - 12	
Cancer jordani	hairy rock crab	1	29	5.1	7	14 - 21	0.9 - 3.5
Cancer magister	Dungeness crab	1	26	5.2			
Cancer spp.	cancer crabs	1	10	0.8	1	9	2.5
Loxorhynchus crispatus	moss crab				6	8 - 22	0.3 - 9.0
Loxorhynchus spp.	spider crabs				1	6	3.3
Pachygrapsus crassipes	striped shore crab				1	9	0.5
Pugettia producta	northern kelp crab				23	6 - 45	0.1 - 36.3
Pugettia richii	cryptic kelp crab				7	5 - 15	0.1 - 6.5
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	15	8 - 14	1.2 - 4.6	7	8 - 16	0.8 - 4.3
Crangon nigromaculata	spotted bay shrimp				1	10	0.9
Upogebia pugettensis	blue mud shrimp				1	20	7.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0035	05/04/00	05/05/00	24	24	24	24	0	0	24	24

Table H1-36. Morro Bay Power Plant Impingement Abundance Survey 36, May 11, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt				1	153	30.7
Citharichthys sordidus	Pacific sanddab				1	62	2.0
Citharichthys stigmaeus	speckled sanddab				15	31 - 54	0.6 - 1.8
Engraulis mordax	northern anchovy				2	41 - 55	1.3
Leptocottus armatus	Pacific staghorn sculpin				1	60	3.8
Porichthys notatus	plainfin midshipmen				9	120 - 196	17.1 - 59.0
Syngnathus spp.	pipefishes				1	100	2.0
Crabs							
Cancer antennarius	brown rock crab				2	35 - 44	8.5 - 16.0
Cancer gracilis	slender rock crab				1	29	4.0
Cancer spp.	cancer crabs				7	4 - 17	0.1 - 1.6
Loxorhynchus crispatus	moss crab				1	8	0.8
Portunus xantusii	Xantus' swimming crab				2	51 - 64	16.1 - 32.9
Pugettia producta	northern kelp crab				8	5 - 21	0.1 - 4.3
Pugettia richii	cryptic kelp crab				3	5 - 10	0.1 - 0.8
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				3	9 - 15	0.7 - 3.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0036	05/11/00	05/12/00	0	0	0	0	0	0	24	24

Table H1-37. Morro Bay Power Plant Impingement Abundance Survey 37, May 18, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				1	660	516.0
Teleosts							
Amphistichus argenteus	barred surfperch				1	54	4.6
Artedius notospilotus	bonyhead sculpin				1	77	10.5
Atherinops affinis	topsmelt	4	87 - 134	7.5 - 27.3			
Citharichthys sordidus	Pacific sanddab	1	34	0.6			
Citharichthys stigmaeus	speckled sanddab	36	28 - 80	0.3 - 8.0	10	29 - 53	0.1 - 2.5
Cymatogaster aggregata	shiner surfperch	3	86 - 93	15.2 - 18.7			
Embiotoca lateralis	striped surfperch	2	62	5.5 - 5.8			
Leptocottus armatus	Pacific staghorn sculpin	4	69 - 89	6.2 - 12.0	1	73	5.6
Parophrys vetulus	English sole	10	30 - 46	0.8 - 1.9	5	28 - 50	0.4 - 1.4
Porichthys notatus	plainfin midshipmen	4	107 - 223	16.0 - 143.4	4	133 - 185	25.1 - 67.0
Syngnathus leptorhynchus	bay pipefish	1	210	2.6			
Crabs							
Cancer antennarius	brown rock crab	3	22 - 40	1.8 - 14.3	5	20 - 80	2.3 - 36.2
Cancer anthonyi	yellow rock crab	2	11 - 18	0.4 - 1.3	13	11 - 24	0.7 - 3.9
Cancer gracilis	slender rock crab				2	16 - 24	1.3 - 2.6
Cancer jordani	hairy rock crab	6	15 - 36	1.8 - 8.7	4	11 - 27	0.2 - 6.5
Cancer productus	red rock crab	1	-	10.5	2	81 - 98	96.0 - 99.2
Cancer spp.	cancer crabs	3	11 - 23	0.4 - 2.8	9	11 - 21	0.5 - 2.5
Loxorhynchus crispatus	moss crab				1	20	4.4
Loxorhynchus spp.	spider crabs				1	24	12.6
Pachygrapsus crassipes	striped shore crab				1	28	10.2
Portunus xantusii	Xantus' swimming crab	1	52	20.2			
Pugettia gracilis	graceful kelp crab				2	10 - 13	0.5 - 1.0
Pugettia producta	northern kelp crab				14	6 - 16	0.4 - 1.9
Pugettia richii	cryptic kelp crab				8	7 - 23	0.1 - 4.8
Shrimps							
Crangon alaskensis		1	14	2.2			
Crangon franciscorum	Franciscan bay shrimp	11	8 - 13	0.7 - 2.7			
Crangon nigricauda	black-tailed bay shrimp	42	7 - 15	0.5 - 3.3	18	10 - 14	1.4 - 3.5
Crangon spp.	bay shrimp				1	12	1.3
Heptacarpus palpator	stout bodied shrimp	1	12	1.1			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				3	9 - 38	0.7 - 21.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0037	05/18/00	05/19/00	24	24	22	24	4	4	24	24

Table H1-38. Morro Bay Power Plant Impingement Abundance Survey 38, May 25, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	560	-			
Teleosts							
Atherinops affinis	topsmelt	4	33 - 141	4.9 - 29.5	1	145	36.3
Chilara taylori	spotted cusk-eel	1	240	70.0			
Citharichthys sordidus	Pacific sanddab	5	41 - 58	1.7 - 3.7			
Citharichthys spp.	sanddabs				1	35	1.0
Citharichthys stigmaeus	speckled sanddab	26	32 - 79	0.5 - 6.5	10	31 - 70	0.7 - 7.6
Cymatogaster aggregata	shiner surfperch	1	122	45.0	1	110	29.1
Eopsetta exilis	slender sole				1	27	0.1
Genyonemus lineatus	white croaker	1	47	2.2			
Leptocottus armatus	Pacific staghorn sculpin	1	70	8.9	1	160	67.4
Parophrys vetulus	English sole	2	42 - 45	1.5 - 3.5	1	35	1.0
Pholididae/Stichaeidae unid.					2	25 - 32	0.1
Porichthys notatus	plainfin midshipmen	48	109 - 240	16.2 - 145.6	94	97 - 282	13.8 - 88.8
Sebastes serranoides	olive rockfish				1	38	1.0
Syngnathus leptorhynchus	bay pipefish				1	168	0.9
Syngnathus spp.	pipefishes	1	165	3.8			
Crabs							
Cancer antennarius	brown rock crab	2	11 - 13	0.6 - 0.8	4	15 - 30	1.0 - 6.9
Cancer antennarius/C. jordani	cancer crabs				1	17	1.0
Cancer jordani	hairy rock crab	1	24	3.7	4	12 - 19	1.0 - 1.8
Cancer magister	Dungeness crab				4	13 - 16	0.9 - 1.2
Cancer spp.	cancer crabs	1	10	0.4	1	13	0.5
Loxorhynchus crispatus	moss crab				1	8	0.6
Pachycheles pubescens	pubescent porcelain crab	1	7	0.3			
Pachygrapsus crassipes	striped shore crab				1	10	0.5
Portunus xantusii	Xantus' swimming crab	3	50 - 54	17.6 - 27.8	2	49 - 66	13.5 - 37.6
Pugettia producta	northern kelp crab	2	21 - 30	5.6 - 11.0	13	5 - 36	0.1 - 21.3
Pugettia richii	cryptic kelp crab	1	16	5.0	10	5 - 14	0.1 - 1.5
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	15	7 - 13	0.6 - 5.5	18	6 - 12	0.8 - 5.5
Crangon nigromaculata	spotted bay shrimp	3	8 - 11	1.1 - 2.3			
Cephalopods							
Loligo opalescens	market squid	1	120	19.8			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	4	25 - 32	4.7 - 9.1	1	26	12.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0038	05/25/00	05/26/00	24	24	24	24	24	24	24	24

Table H1-39. Morro Bay Power Plant Impingement Abundance Survey 39, June 1, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				3	180 - 530	310.5 - 465.0
Platyrhinoidis triseriata	thornback	1	675	1994.0	4	410 - 590	530.0 - 965.0
Triakis semifasciata	leopard shark	1	210	30.0			
Teleosts							
Amphistichus argenteus	barred surfperch	1	47	2.0	1	52	3.9
Atherinops affinis	topsmelt	2	145 - 153	27.8 - 38.6	5	140 - 167	22.7 - 35.3
Aulorhynchus flavidus	tubesnout				1	96	1.3
Chilara taylori	spotted cusk-eel	5	122 - 270	42.8 - 76.8	1	140	13.0
Citharichthys sordidus	Pacific sanddab	4	33 - 43	1.0 - 5.0			
Citharichthys spp.	sanddabs	1	-	-	1	36	1.2
Citharichthys stigmaeus	speckled sanddab	39	30 - 90	0.4 - 12.6	46	29 - 81	0.2 - 7.6
Cymatogaster aggregata	shiner surfperch	3	84 - 113	14.8 - 38.1			
Embiotoca lateralis	striped surfperch				1	65	5.7
Engraulis mordax	northern anchovy	4	83 - 132	6.4 - 18.2	1	123	19.0
Gobiesox maeandricus	northern clingfish				1	50	3.3
Hyperprosopon argenteum	walleye surfperch				1	50	3.0
Lepidogobius lepidus	bay goby	1	9	0.8			
Leptocottus armatus	Pacific staghorn sculpin	41	58 - 110	2.7 - 17.8	14	53 - 95	2.3 - 9.4
Ophidion scrippsae	basketweave cusk-eel	1	200	5.3			
Ophiodon elongatus	lingcod	13	77 - 103	3.4 - 8.7	8	80 - 110	3.0 - 11.0
Orthonopias triacis	snubnose sculpin	1	31	1.4			
Parophrys vetulus	English sole	44	31 - 62	0.5 - 3.9	12	21 - 51	0.2 - 1.8
Pleuronichthys coenosus	c-o turbot				1	30	0.9
Porichthys notatus	plainfin midshipmen	42	110 - 231	13.7 - 138.8	42	105 - 225	14.0 - 142.0
Scorpaenichthys marmoratus	cabezon	1	39	1.7			
Sebastes caurinus	copper rockfish	1	73	10.9			
Sebastes paucispinis	boccacio	2	53 - 70	2.3 - 4.8			
Symphurus atricauda	California tonguefish				2	86 - 97	4.7 - 7.7
Syngnathus leptorhynchus	bay pipefish				3	145 - 189	2.6 – 4.0
Syngnathus spp.	pipefishes	1	171	1.1			
Crabs							
Cancer antennarius	brown rock crab	1	57	43.5	14	18 - 86	1.7 - 84.0
Cancer antennarius/C. jordani	cancer crabs	2	22 - 32	1.3 - 3.2			
Cancer anthonyi	yellow rock crab				4	19 - 43	0.8 - 13.8
Cancer gracilis	slender rock crab				1	18	0.8
Cancer jordani	hairy rock crab	1	16	1.0	13	15 - 25	0.1 - 2.7
Cancer magister	Dungeness crab	3	11 - 120	0.3 - 214.3	6	8 - 16	0.1 - 0.6
Cancer productus	red rock crab				1	13	0.2
Cancer spp.	cancer crabs	1	12	0.8	15	9 - 30	0.1 - 4.2
Loxorhynchus crispatus	moss crab				2	14 - 20	1.9 - 5.6
Pachygrapsus crassipes	striped shore crab				2	14 - 17	1.1 - 3.0
Portunus xantusii	Xantus' swimming crab				5	22 - 62	1.2 - 33.5
Pugettia producta	northern kelp crab	8	16 - 25	2.0 - 7.3	16	8 - 50	0.4 - 62.3
Pugettia richii	cryptic kelp crab	1	10	0.2	4	7 - 17	0.2 - 2.0
Shrimps							
Crangon franciscorum	Franciscan bay shrimp	2	11 - 12	1.7 - 2.3			
Crangon nigricauda	black-tailed bay shrimp	352	7 - 17	0.3 - 3.4	215	6 - 17	0.2 - 3.7
Crangon nigromaculata	spotted bay shrimp	7	1 - 14	1.1 - 3.1	2	12 - 13	1.3
Crangon spp.	bay shrimp				2	10	0.6
Heptacarpus spp.	tidepool shrimps				1	7	0.6
Hippolytidae unid.	Hippolytid shrimps	1	12	0.7			
Cephalopods							
Loligo opalescens	market squid	3	45 - 71	2.8 - 10.4	2	46 - 80	3.2 - 11.6
Octopus spp.	octopus				1	97	

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0039	06/01/00	06/02/00	24	24	24	24	24	24	24	24

Table H1-40. Morro Bay Power Plant Impingement Abundance Survey 40, June 8, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray				1	420	171.9
Teleosts							
Amphistichus argenteus	barred surfperch	1	47	2.7	1	59	7.2
Artedius spp.	sculpins				1	61	4.7
Chilara taylori	spotted cusk-eel	1	157	14.7	1	212	29.7
Citharichthys stigmaeus	speckled sanddab	3	39 - 81	0.7 - 8.7	2	51	1.7
Cymatogaster aggregata	shiner surfperch	1	92	21.0			
Embiotoca lateralis	striped surfperch				1	60	5.5
Engraulis mordax	northern anchovy				1	121	15.9
Hyperprosopon argenteum	walleye surfperch	1	62	7.9			
Hypsoblennius gilberti	rockpool blenny	1	122	40.3			
Hypsurus caryi	rainbow surfperch	1	68	8.3	1	70	12.2
Leptocottus armatus	Pacific staghorn sculpin				1	56	3.5
Neoclinus uninotatus	onespot fringehead				1	112	11.8
Ophiodon elongatus	lingcod	3	64 - 106	3.1 - 10.5	3	83 - 89	4.0 - 4.6
Parophrys vetulus	English sole	3	41 - 47	1.1 - 1.7	8	38 - 57	0.9 - 3.0
Phanerodon furcatus	white surfperch	2	48 - 173	2.7 - 12.5			
Pleuronichthys decurrens	curlfin turbot	1	37	1.6			
Porichthys notatus	plainfin midshipmen	55	105 - 178	13.1 - 90.9	149	94 - 192	10.8 - 93.3
Scorpaenichthys marmoratus	cabezon	1	300	777.0			
Sebastes goodei	chilipepper	1	125	28.2			
Syngnathus leptorhynchus	bay pipefish	1	175	2.9			
Crabs							
Cancer antennarius	brown rock crab	2	33 - 61	7.1 - 39.9	7	14 - 54	0.7 - 32.2
Cancer anthonyi	yellow rock crab				1	12	0.5
Cancer jordani	hairy rock crab	2	19 - 24	1.8 - 2.0	9	14 - 51	0.8 - 20.8
Cancer productus	red rock crab	1	66	34.6	1	28	3.3
Cancer spp.	cancer crabs	3	10 - 16	0.4 - 1.2	5	12 - 18	0.5 - 1.4
Loxorhynchus crispatus	moss crab				6	10 - 14	0.6 - 2.0
Loxorhynchus spp.	spider crabs				1	13	1.4
Pachygrapsus crassipes	striped shore crab				1	29	8.9
Portunus xantusii	Xantus' swimming crab				4	50 - 57	15.7 - 26.7
Pugettia producta	northern kelp crab				7	7 - 21	0.8 - 4.3
Pugettia richii	cryptic kelp crab	3	12 - 15	0.9 - 8.0	1	19	2.2
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	20	8 - 13	0.5 - 2.3	19	4 - 13	1.2 - 4.2
Crangon nigromaculata	spotted bay shrimp	1	12	1.5	3	7 - 13	0.4 - 3.2
Penaeus californiensis	brown shrimp				1	66	42.3
Cephalopods							
Loligo opalescens	market squid	9	33 - 52	2.7 - 7.4	5	26 - 46	1.6 - 4.5
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	9	15 - 39	1.5 - 22.8			

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0040	06/08/00	06/09/00	10	2	24	24	24	24	24	24

Table H1-41. Morro Bay Power Plant Impingement Abundance Survey 41, June 15, 2000.

		Units 1 and 2*			Units 3 and 4*		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	500	940.0	2	600 - 610	1010.0 - 1390.0
Teleosts							
Amphistichus argenteus	barred surfperch				1	36	15.0
Apodichthys flavidus	penpoint gunnel				1	210	29.9
Atherinops affinis	topsmelt				1	-	-
Chilara taylori	spotted cusk-eel	2	144 - 202	13.5 - 51.5			
Citharichthys stigmaeus	speckled sanddab	11	32 - 80	0.3 - 8.9	6	30 - 75	0.7 - 6.8
Cymatogaster aggregata	shiner surfperch	3	80 - 106	10.1 - 29.5	1	85	14.8
Embiotoca jacksoni	black surfperch	1	55	4.7			
Embiotoca lateralis	striped surfperch	1	70	8.5			
Engraulis mordax	northern anchovy	2	73 - 85	3.0 - 5.7			
Genyonemus lineatus	white croaker	1	42	1.4			
Hyperprosopon argenteum	walleye surfperch	1	48	-			
Hypsurus caryi	rainbow surfperch	1	51	3.9			
Icichthys lockingtoni	medusa fish	1	35	3.0			
Leptocottus armatus	Pacific staghorn sculpin	28	60 - 129	2.7 - 34.0	5	59 - 115	3.0 - 16.5
Microstomus pacificus	Dover sole				1	17	2.0
Ophidion scrippsae	basketweave cusk-eel	1	199	46.8			
Parophrys vetulus	English sole	14	30 - 66	0.7 - 2.7	4	40 - 56	1.3 - 3.6
Phanerodon furcatus	white surfperch	2	40 - 50	1.9 - 2.1			
Porichthys notatus	plainfin midshipmen	7	136 - 152	25.6 - 48.4	4	135 - 160	23.2 - 41.7
Scorpaenichthys marmoratus	cabezon	1	44	2.3			
Sebastes melanops	black rockfish	1	41	0.7			
Syngnathus leptorhynchus	bay pipefish				1	185	1.5
Crabs							
Cancer antennarius	brown rock crab	2	24 - 57	2.2 - 25.2	3	22 - 35	2.3 - 10.8
Cancer anthonyi	yellow rock crab				1	16	0.8
Cancer gracilis	slender rock crab	1	18	0.8			
Cancer jordani	hairy rock crab	3	14 - 17	0.5 - 1.3	8	12 - 19	0.8 - 2.2
Loxorhynchus crispatus	moss crab				1	15	2.1
Podochela hemphilli	Hemphill's kelp crab	1	12	1.2			
Portunus xantusii	Xantus' swimming crab	5	50 - 87	17.4 - 58.3			
Pugettia producta	northern kelp crab	1	48	45.2	1	17	2.9
Pugettia richii	cryptic kelp crab				1	10	0.7
Pugettia spp.	kelp crabs	1	55	-			
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	37	3 - 14	0.2 - 3.1	16	8 - 12	0.8 - 2.6
Crangon nigromaculata	spotted bay shrimp	10	11 - 14	0.4 - 3.5	4	10 - 13	1.5 - 3.3
Hippolytidae unid.	Hippolytid shrimps	1	7	0.6			
Cephalopods							
Loligo opalescens	market squid	16	38 - 62	1.1 - 6.6			

* N = 3, Cycles 4-6 were not sampled. During sample collection, the welds on the collection basket broke.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0041	06/15/00	06/16/00	24	24	24	24	24	24	24	24

Table H1-42. Morro Bay Power Plant Impingement Abundance Survey 42, June 22, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	700	1135.0			
Teleosts							
Amphistichus argenteus	barred surfperch	1	59	6.4			
Atherinops affinis	topsmelt				2	139 - 140	22.5 - 28.5
Aulorhynchus flavidus	tubesnout				1	90	1.0
Chilara taylori	spotted cusk-eel	1	243	56.5			
Citharichthys sordidus	Pacific sanddab	1	65	3.6			
Citharichthys stigmaeus	speckled sanddab	1	38	1.8	1	95	9.0
Engraulis mordax	northern anchovy	873	72 - 131	2.0 – 19.7	6921	68 - 145	2.1 – 26.7
Hexagrammos decagrammus	kelp greenling	1	69	5.7			
Hyperprosopon argenteum	walleye surfperch	1	50	3.2			
Hypsoblennius gilberti	rockpool blenny	1	87	11.4			
Leptocottus armatus	Pacific staghorn sculpin	2	65 - 101	4.8 - 13.1	2	81 - 84	8.2 - 10.0
Ophiodon elongatus	lingcod	2	91 - 92	5.1 - 6.5			
Parophrys vetulus	English sole	25	54 - 77	2.8 - 10.7	1	80	4.8
Phanerodon furcatus	white surfperch				1	203	-
Porichthys notatus	plainfin midshipmen	30	110 - 192	16.3 - 89.6	33	82 - 190	9.4 - 70.4
Sardinops sagax	Pacific sardine				4	140 - 162	30.2 - 47.4
Scorpaenichthys marmoratus	cabezon	1	73	10.0			
Sebastes caurinus	copper rockfish	1	35	0.8			
Sebastes chrysomelas	black & yellow rockfish				1	132	31.5
Stellerina xyosterna	pricklebreast poacher	1	78	3.3			
Syngnathus spp.	pipefishes	2	124 - 165	1.2 - 3.0	2	220 - 242	2.6 - 6.3
Crabs							
Cancer antennarius	brown rock crab	1	64	55.3	11	14 - 80	1.2 - 88.0
Cancer anthonyi	yellow rock crab				1	15	1.1
Cancer gracilis	slender rock crab				2	17 - 23	1.1 - 3.8
Cancer jordani	hairy rock crab	2	14 - 24	1.7 - 4.1	3	19 - 24	2.0 - 3.3
Cancer magister	Dungeness crab				1	20	1.6
Cancer spp.	cancer crabs	2	18 - 19	1.9	2	10 - 20	0.4 - 2.1
Loxorhynchus crispatus	moss crab	1	120	-	1	19	4.0
Portunus xantusii	Xantus' swimming crab	1	57	24.3	5	50 - 61	17.1 - 29.3
Pugettia producta	northern kelp crab	4	23 - 51	6.2 - 96.5	7	6 - 25	1.3 - 7.0
Pugettia richii	cryptic kelp crab				4	7 - 13	0.6 - 1.5
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	13	12 - 14	0.6 - 3.8	3	11 - 13	2.3 - 3.0
Crangon nigromaculata	spotted bay shrimp				2	12 - 15	2.3 - 3.3
Cephalopods							
Loligo opalescens	market squid	1825	27 - 59	1.1 – 6.8	666	25 - 63	0.3 – 6.9
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				1	8	0.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0042	06/22/00	06/23/00	24	24	24	24	24	24	24	24

Table H1-43. Morro Bay Power Plant Impingement Abundance Survey 43, June 29, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	1	450	490.0			
Teleosts							
Amphistichus argenteus	barred surfperch	1	37	3.7			
Artedius lateralis	smoothhead sculpin	1	88	15.3			
Aulorhynchus flavidus	tubesnout	2	88 - 150	0.8 - 8.0	1	114	1.0
Citharichthys stigmaeus	speckled sanddab	6	36 - 85	0.8 - 10.9			
Cymatogaster aggregata	shiner surfperch	2	102 - 113	29.5 - 39.5	4	68 - 192	8.1 - 16.5
Damalichthys vacca	pile surfperch	1	41	2.4			
Embiotoca lateralis	striped surfperch	3	57 - 75	4.7 - 11.5			
Engraulis mordax	northern anchovy	176	72 - 124	3.8 – 20.8	8	90 - 116	6.8 – 16.1
Heterostichus rostratus	giant kelpfish				1	81	8.2
Hyperprosopon argenteum	walleye surfperch	1	53	3.7	3	38 - 50	1.7 - 2.8
Hypsurus caryi	rainbow surfperch	1	35	3.5			
Icichthys lockingtoni	medusa fish	4	42 - 190	1.0 - 91.0	5	55 - 172	1.8 - 36.8
Leptocottus armatus	Pacific staghorn sculpin	5	68 - 99	5.8 - 14.3	5	82 - 193	10.1 - 13.3
Parophrys vetulus	English sole	2	56 - 66	3.5 - 5.0			
Peprilus simillimus	Pacific butterfish	1	41	1.3			
Porichthys notatus	plainfin midshipmen	3	135 - 139	22.4 - 37.5			
Scorpaenichthys marmoratus	cabezon	4	42 - 61	1.9 - 6.5			
Sebastes chrysomelas/S. carnatus (yoy)		1	48	1.4			
Sebastes serranoides	olive rockfish	1	42	1.3			
larval/post-larval fish, unid.	unid. larval fishes	1*	-	-			
Crabs							
Cancer antennarius	brown rock crab	25	16 - 61	1.4 - 49.7	14	23 - 104	3.8 - 106.6
Cancer gracilis	slender rock crab	1	15	1.0			
Cancer jordani	hairy rock crab	8	14 - 27	1.4 - 6.0	2	21 - 26	3.1 - 5.5
Cancer magister	Dungeness crab	1	20	1.0			
Cancer productus	red rock crab	1	43	11.0	1	21	2.0
Cancer spp.	cancer crabs	1	17	2.0	3	17 - 19	2.2 - 2.7
Lophopanopeus spp.	black-clawed crabs	1	16	1.9			
Loxorhynchus crispatus	moss crab				3	11 - 19	2.2 - 5.6
Pachygrapsus crassipes	striped shore crab	1	17	2.9			
Portunus xantusii	Xantus' swimming crab				1	52	18.3
Pugettia producta	northern kelp crab	7	12 - 45	1.2 - 40.3	9	9 - 33	0.7 - 14.7
Pugettia richii	cryptic kelp crab				3	11 - 12	1.2 - 1.9
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	6	11 - 13	0.6 - 3.2			
Cephalopods							
Loligo opalescens	market squid				2	24 - 48	1.1 - 4.0
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	5	15 - 39	13.7 - 24.2	2	20 - 29	4.8 - 12.1

*Specimen was mutilated. No length nor weight was measured.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0043	06/29/00	06/30/00	24	24	24	24	24	24	24	24

Table H1-44. Morro Bay Power Plant Impingement Abundance Survey 44, July 6, 2000.

		Units 1 and 2*			Units 3 and 4**		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				1	390	355.5
Teleosts							
Amphistichus argenteus	barred surfperch				1	60	4.9
Atherinidae unid.	silversides				2		2.2 - 26.6
Citharichthys stigmaeus	speckled sanddab				3	68 - 90	0.5 - 9.5
Clinocottus spp.	sculpins	1	52	3.1			
Cymatogaster aggregata	shiner surfperch				5	83 - 111	13.0 - 27.3
Embiotocidae	surfperches				2	59 - 60	5.4 - 6.2
Embiotocidae unid. (juv.)					1	-	-
Engraulis mordax	northern anchovy	6	80 - 90	1.8 - 3.2	6	83 - 140	0.7 - 21.9
Gobiesox maeandricus	northern clingfish	1	40	1.2			
Icichthys lockingtoni	medusa fish				1	-	-
Leptocottus armatus	Pacific staghorn sculpin				1	78	7.6
Parophrys vetulus	English sole				1	70	5.7
Peprilus simillimus	Pacific butterfish				2	27 - 29	0.4 - 0.4
Porichthys notatus	plainfin midshipmen				1	169	62.6
Syngnathus spp.	pipefishes				2	178 - 192	2.0 - 3.3
Crabs							
Cancer antennarius	brown rock crab	2	37 - 38	10.5 - 11.1	26	17 - 80	0.5 - 108.7
Cancer jordani	hairy rock crab	1	30	7.3	4	8 - 18	0.1 - 1.3
Cancer magister	Dungeness crab				2	26 - 35	2.4 - 6.0
Cancer productus	red rock crab				1	62	30.5
Cancer spp.	cancer crabs	5	10 - 17	0.6 - 1.4	15	13 - 29	0.2 - 3.2
Loxorhynchus crispatus	moss crab				4	7 - 26	0.8 - 6.2
Pachygrapsus crassipes	striped shore crab				2	16 - 21	0.8 - 3.0
Portunus xantusii	Xantus' swimming crab	1	54	18.5	8	47 - 60	6.4 - 33.5
Pugettia producta	northern kelp crab	2	11 - 20	1.9 - 5.5	11	10 - 27	0.5 - 11.3
Pugettia richii	cryptic kelp crab	1	16	0.9	8	6 - 16	0.5 - 1.3
Cephalopods							
Loligo opalescens	market squid	1	90	18.0	1	46	3.0
Octopus spp.	octopus				1	90	304.5
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	29	8.5	6	19 - 44	3.2 - 36.6

* N = 4, Cycles 5-6 were not sampled. Heavy amounts of debris required continuous screen washing, so samples could not be collected.

** N = 3, Cycles 4-6 were not sampled. Heavy amounts of debris required continuous screen washing, so samples could not be collected.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0044	07/06/00	07/07/00	6	20	0	0	24	24	24	24

Table H1-45. Morro Bay Power Plant Impingement Abundance Survey 45, July 13, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Myliobatis californica	bat ray	1	410	265.5			
Torpedo californica	Pacific electric ray				1	190	139.0
Teleosts							
Amphistichus argenteus	barred surfperch	1	58	4.3			
Artedius lateralis	smoothhead sculpin	1	47	4.0			
Atherinops affinis	topsmelt	1	115	15.2	1	142	-
Citharichthys sordidus	Pacific sanddab				2	43 - 71	1.7 - 5.5
Citharichthys spp.	sanddabs				1	-	3.5
Citharichthys stigmaeus	speckled sanddab	6	43 - 70	1.1 - 6.8	1	39	0.4
Cymatogaster aggregata	shiner surfperch	1	98	18.7	1	110	29.0
Embiotoca jacksoni	black surfperch				1	280	84.7
Embiotocidae	surfperches				2	33	1.1 - 1.5
Gibbonsia spp.	clinid kelpfishes	1	100	7.8			
Gillichthys mirabilis	longjaw mudsucker	1	65	4.6			
Leptocottus armatus	Pacific staghorn sculpin	2	87	12.5 - 13.0	2	70 - 86	6.2 - 12.1
Parophrys vetulus	English sole				2	75 - 76	7.1 - 8.4
Phanerodon furcatus	white surfperch				1	55	5.1
Porichthys notatus	plainfin midshipmen				2	115 - 138	20.4 - 28.4
Scorpaenichthys marmoratus	cabezon	1	51	3.5	2	51 - 66	3.5 - 7.6
Sebastes spp.	rockfishes	1	35	0.6			
Syngnathus leptorhynchus	bay pipefish				2	210 - 215	4.1 - 8.8
Syngnathus spp.	pipefishes	2	175 - 200	0.9 - 1.2			
Crabs							
Cancer antennarius	brown rock crab	8	28 - 70	4.6 - 72.3	28	17 - 61	1.40 - 51.9
Cancer antennarius/C. jordani	cancer crabs				2	23 - 23	4.5 - 5.1
Cancer gracilis	slender rock crab	3	32 - 45	4.4 - 11.4	2	12 - 13	1.3
Cancer jordani	hairy rock crab	2	21 - 25	2.9 - 3.4	5	12 - 27	0.7 - 5.6
Cancer magister	Dungeness crab				1	18	2.2
Cancer productus	red rock crab				14	13 - 64	0.5 - 31.4
Cancer spp.	cancer crabs	19	12 - 25	0.8 - 5.2	24	9 - 21	0.1 - 3.0
Hemigrapsus nudus	purple shore crab				1	-	-
Lophopanopeus spp.	black-clawed crabs				2	18	1.7 - 3.5
Loxorhynchus crispatus	moss crab				7	8 - 14	0.1 - 3.0
Pachygrapsus crassipes	striped shore crab				2	15 - 18	2.2 - 3.0
Pelia tumida	dwarf crab				1	13	1.4
Portunus xantusii	Xantus' swimming crab	6	52 - 59	16.8 - 30.2	5	49 - 56	5.9 - 25.9
Pugettia producta	northern kelp crab	7	13 - 36	0.5 - 21.1	15	8 –29	0.1 – 10.4
Pugettia richii	cryptic kelp crab	1	16	2.3	2	5 - 13	0.8 - 2.1
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	9	8 - 14	1.3 - 5.1	2	10	3.0
Crangon nigromaculata	spotted bay shrimp	2	13	4.0 - 4.2	3	14	3.1 - 3.8
Crangon spp.	bay shrimp	1	14	3.5			
Pandalus spp.	unidentified shrimp				3	10 - 15	0.2 - 0.9
Upogebia pugettensis	blue mud shrimp				1	24	11.6
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	15 - 32	2.0 - 14.2	7	6 - 40	1.0 - 25.2

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0045	07/13/00	07/14/00	24	24	24	24	24	23	24	24

Table H1-46. Morro Bay Power Plant Impingement Abundance Survey 46, July 20, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Teleosts							
Atherinops affinis	topsmelt	2	54 - 78	1.3 - 4.3	2	88 - 91	5.6 - 6.4
Citharichthys sordidus	Pacific sanddab				1	52	1.8
Citharichthys stigmaeus	speckled sanddab				2	62 - 71	3.5 - 5.7
Cymatogaster aggregata	shiner surfperch	1	67	9.2	2	100 - 102	22.2 - 34.9
Engraulis mordax	northern anchovy				6	12 - 130	20.2 - 23.1
Hyperprosopon argenteum	walleye surfperch				1	47	2.4
Parophrys vetulus	English sole	2	71 - 80	5.6 - 6.9	2	71 - 71	6.4 - 7.7
Sardinops sagax	Pacific sardine				5	164 - 203	55.2 - 107.7
Scomber japonicus	Pacific mackerel	1	-	-			
Scorpaenichthys marmoratus	cabezon	1	80	13.4			
Sebastes rastrelliger	grass rockfish				1	192	167.6
Sebastes spp.	rockfishes				1	58	4.6
Syngnathus leptorhynchus	bay pipefish				1	182	1.1
Syngnathus spp.	pipefishes	1	190	2.8			
Crabs							
Cancer antennarius	brown rock crab	3	29 - 70	7.6 - 70.4	11	19 - 59	1.3 - 50.0
Cancer antennarius/C. jordani	cancer crabs	9	20 - 24	0.3 - 3.4	6	15 - 69	0.8 - 72.7
Cancer anthonyi	yellow rock crab	2	52 - 64	22.7 - 40.4			
Cancer gracilis	slender rock crab	1	31	5.1			
Cancer jordani	hairy rock crab	7	20 - 23	2.5 - 4.1	9	8 - 27	1.0 - 4.1
Cancer magister/gracilis	cancer crabs				2	12 - 19	0.6 - 2.0
Cancer spp.	cancer crabs	11	12 - 25	0.7 - 5.5	10	9 - 72	0.5 - 3.2
Loxorhynchus crispatus	moss crab				3	10 - 14	0.9 - 1.6
Pachycheles spp.	porcelain crabs				1	14	2.3
Pachygrapsus crassipes	striped shore crab	1	10	0.8	2	16 - 17	1.6 - 2.8
Portunus xantusii	Xantus' swimming crab	2	52 - 55	11.8 - 23.1	6	50 - 54	13.1 - 19.9
Pugettia producta	northern kelp crab	13	12 - 50	0.6 - 49.3	5	7 - 29	0.3 - 12.4
Pugettia richii	cryptic kelp crab	1	14	0.5	8	9 - 31	0.5 - 21.4
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	5	1 - 15	0.8 - 3.8	2	10 - 14	2.2 - 2.8
Crangon nigromaculata	spotted bay shrimp				3	9 - 13	1.1 - 3.3
Heptacarpus spp.	tidepool shrimps				1	6	1.2
Cephalopods							
Loligo opalescens	market squid	1	51	4.9	1	59	7.2
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	35	18.5	2	5 - 7	0.5 - 3.7

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0046	07/20/00	07/21/00	24	24	24	24	24	24	24	24

Table H1-47. Morro Bay Power Plant Impingement Abundance Survey 47, July 27, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				1	512	818.3
Teleosts							
Artedius spp.	sculpins	2	47 - 58	2.1 - 3.6			
Atherinops affinis	topsmelt	3	90 - 115	7.9 - 18.3	2	95 - 96	7.5 - 8.5
Chilara taylori	spotted cusk-eel	2	130 - 212	9.8 - 61.1	1	184	36.1
Citharichthys stigmaeus	speckled sanddab	10	43 - 82	1.7 - 9.6	4	42 - 88	1.2 - 12.7
Cymatogaster aggregata	shiner surfperch	2	46 - 63	2.8 - 5.8	1	44	2.3
Engraulis mordax	northern anchovy	1	135	22.1	6	65 - 140	2.5 - 23.4
Gibbonsia spp.	clinid kelpfishes	1	90	6.1			
Leptocottus armatus	Pacific staghorn sculpin	11	78 - 100	8.2 - 16.0	5	83 - 92	9.5 - 13.2
Parophrys vetulus	English sole				1	35	0.6
Peprilus simillimus	Pacific butterfish	1	37	1.0			
Phanerodon furcatus	white surfperch	1	54	3.3			
Sardinops sagax	Pacific sardine	1	190	88.6	5	170 - 205	57.6 - 108.8
Scorpaenichthys marmoratus	cabezon	2	53 - 60	2.5 - 4.0	1	42	2.3
Sebastes spp.	rockfishes	1	43	2.1	1	61	5.0
Sebastes spp. (juv.)	rockfishes	1	48	2.7			
Syngnathus leptorhynchus	bay pipefish	1	184	1.5			
Syngnathus spp.	pipefishes	2	110 - 197	2.1 - 3.2	3	131 - 203	0.5 - 2.4
Ulvicola sanctaerosae	kelp gunnel	1	90	2.2			
Xererpes fucorum	rockweed gunnel				1	110	9.8
Crabs							
Cancer antennarius	brown rock crab	10	21 - 101	1.6 - 290.3	9	21 - 43	1.8 - 27.9
Cancer antennarius/C. jordani	cancer crabs	5	15 - 21	1.5 - 2.4	3	15 - 17	0.6 - 1.1
Cancer anthonyi	yellow rock crab	3	22 - 28	3.1 - 4.3	3	17 - 23	0.5 - 3.0
Cancer gracilis	slender rock crab	10	16 - 40	1.7 - 10.6	6	20 - 34	1.6 - 5.7
Cancer jordani	hairy rock crab	16	14 - 28	1.5 - 6.9	4	15 - 19	0.8 - 1.1
Cancer magister	Dungeness crab	1	28	4.0			
Cancer magister/gracilis	cancer crabs	1	13	0.5	4	16 - 25	1.0 - 2.8
Cancer productus	red rock crab	1	57	13.8	2	30 - 34	3.3 - 5.0
Cancer spp.	cancer crabs	36	10 - 23	0.1 - 3.8	23	10 - 19	0.3 - 2.0
Hemigrapsus nudus	purple shore crab				1	14	0.8
Lophopanopeus leucomanus					1	16	2.1
Lophopanopeus spp.	black-clawed crabs	1	18	2.8	1	25	8.5
Loxorhynchus crispatus	moss crab				1	23	7.5
Portunus xantusii	Xantus' swimming crab				5	16 - 58	13.8 - 24.7
Pugettia producta	northern kelp crab	8	11 - 45	0.5 - 35.5	12	6 - 48	0.2 - 54.6
Pugettia richii	cryptic kelp crab	4	11 - 15	0.6 - 2.2	4	12 - 15	0.9 - 2.1
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	7	10 - 14	1.4 - 3.7	7	9 - 15	0.7 - 3.6
Crangon nigromaculata	spotted bay shrimp	2	12 - 15	1.8 - 3.4	4	12 - 15	1.4 - 3.3
Heptacarpus spp.	tidepool shrimps				1	7	0.3
Pandalus spp.	unidentified shrimp	1	14	2.0	1	12	0.5
Cephalopods							
Loligo opalescens	market squid	1	28	0.3			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin				4	6 - 12	0.1 - 0.4

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0047	07/27/00	07/28/00	23	23	24	24	23	23	24	24

Table H1-48. Morro Bay Power Plant Impingement Abundance Survey 48, August 3, 2000.

Survey canceled owing to maintenance activities.

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0048	08/03/00		24	24	24	24	24	24	23	24

Table H1-49. Morro Bay Power Plant Impingement Abundance Survey 49, August 10, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				1	545	847.0
Teleosts							
Apodichthys flavidus	penpoint gunnel	1	206	24.5			
Atherinidae unid.	silversides				1	47	0.8
Atherinops affinis	topsmelt				1	57	1.2
Chilara taylori	spotted cusk-eel	1	210	54.5			
Cottidae unid.	sculpins	1	48	3.3	2	52 - 160	3.4 - 62.8
Engraulis mordax	northern anchovy				1	51	1.1
Leptocottus armatus	Pacific staghorn sculpin	3	64 - 104	5.5 - 16.6	4	50 - 102	2.7 - 19.1
Sardinops sagax	Pacific sardine				4	179 - 225	63.7 - 90.0
Scorpaenichthys marmoratus	cabezon	1	54	4.3			
Sebastes carnatus	gopher rockfish				1	70	7.5
Syngnathus leptorhynchus	bay pipefish	1	214	3.2	1	153	3.0
Syngnathus spp.	pipefishes				2	92 - 203	0.3 - 3.5
Crabs							
Cancer antennarius	brown rock crab	20	21 - 86	0.9 - 120.3	11	15 - 71	0.9 - 72.0
Cancer antennarius/C. jordani	cancer crabs	5	11 - 22	0.6 - 3.0			
Cancer gracilis	slender rock crab				3	16 - 21	0.8 - 1.8
Cancer jordani	hairy rock crab	19	11 - 43	0.1 - 11.4	8	11 - 29	0.4 - 3.2
Cancer magister	Dungeness crab	1	77	75.2			
Cancer productus	red rock crab				1	41	6.4
Cancer spp.	cancer crabs	15	15 - 25	1.3 - 3.4	11	11 - 31	0.3 - 3.9
Loxorhynchus crispatus	moss crab	2	20 - 24	3.8 - 4.6	2	9 - 17	1.1 - 3.4
Loxorhynchus spp.	spider crabs				1	15	0.8
Podochela hemphilli	Hemphill's kelp crab	1	13	2.6			
Portunus xantusii	Xantus' swimming crab	5	53 - 59	18.3 - 25.0	3	49 - 56	14.5 - 21.4
Pugettia producta	northern kelp crab	6	14 - 48	1.1 - 37.8	10	7 - 69	0.2 - 53.0
Pugettia richii	cryptic kelp crab				4	10 - 19	0.3 - 2.9
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	2	12 - 13	2.4			
Crangon nigromaculata	spotted bay shrimp				1	15	3.3
Crangon spp.	bay shrimp				1	-	-
Pandalus spp.	unidentified shrimp				5	17 - 26	0.6 - 1.1
Cephalopods							
Loligo opalescens	market squid				1	40	2.2
Sea Urchins							
Strongylocentrotus franciscanus	red sea urchin	1	10	0.4			
Strongylocentrotus purpuratus	purple sea urchin	5	10 - 12	0.1 - 1.1	7	9 - 33	0.2 - 14.3

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0049	08/10/00	08/11/00	24	24	24	24	24	24	24	24

Table H1-50. Morro Bay Power Plant Impingement Abundance Survey 50, August 17, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback	2	390 - 451	421.4 - 480.3	1	440	508.0
Teleosts							
Artedius lateralis	smoothhead sculpin	1	94	16.9			
Atherinops affinis	topsmelt				1	100	6.9
Citharichthys stigmaeus	speckled sanddab	1	70	7.2			
Leptocottus armatus	Pacific staghorn sculpin	2	87 - 95	9.0 - 13.8	1	43	3.0
Oligocottus snyderi	fluffy sculpin	1	62	5.7	1	62	5.0
Parophrys vetulus	English sole	1	78	8.7	1	111	19.3
Phanerodon furcatus	white surfperch	1	110	15.0			
Sardinops sagax	Pacific sardine				1	187	74.6
Symphurus atricauda	California tonguefish				1	92	7.5
Crabs							
Cancer antennarius	brown rock crab	20	16 - 76	1.2 - 89.8	4	16 - 48	1.2 - 21.1
Cancer anthonyi	yellow rock crab	1	82	68.6			
Cancer gracilis	slender rock crab	2	23 - 32	2.2 - 6.0			
Cancer jordani	hairy rock crab	8	16 - 39	1.0 - 14.7	10	11 - 25	0.5 - 3.3
Cancer productus	red rock crab	3	110 - 133	173.3 - 234.7			
Cancer spp.	cancer crabs	3	10 - 21	1.0 - 2.4	3	13 - 13	0.5
Portunus xantusii	Xantus' swimming crab	2	46 - 49	11.0 - 16.7			
Pugettia producta	northern kelp crab	8	9 - 44	0.8 - 34.4	4	7 - 18	0.5 - 2.5
Pugettia richii	cryptic kelp crab	1	18	2.6	2	11 - 23	0.1 - 6.6
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	3	10 - 33	1.0 - 3.9			
Hippolytidae unid.	Hippolytid shrimps	1	7	1.0			
Cephalopods							
Loligo opalescens	market squid	1	73	11.4			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	3	7 - 8	0.1 - 0.3	1	9	0.5

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0050	08/17/00	08/18/00	24	24	24	24	19	24	24	24

Table H1-51. Morro Bay Power Plant Impingement Abundance Survey 51, August 24, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Torpedo californica	Pacific electric ray	1	223	192.8			
Teleosts							
Atherinops affinis	topsmelt	1	91	6.4	1	128	16.0
Chilara taylori	spotted cusk-eel	1	195	46.3			
Citharichthys sordidus	Pacific sanddab				1	80	9.0
Citharichthys spp.	sanddabs				1	32	0.6
Citharichthys stigmaeus	speckled sanddab	2	38 - 81	0.4 - 7.8	1	82	9.9
Cymatogaster aggregata	shiner surfperch	1	45	2.6	2	45	3.2
Engraulis mordax	northern anchovy	3	47 - 135	22.0 - 26.2	14	55 - 145	1.0 - 25.5
Leptocottus armatus	Pacific staghorn sculpin	1	93	12.0	2	93 - 108	12.0 - 17.0
Sardinops sagax	Pacific sardine				1	195	85.6
Scorpaenichthys marmoratus	cabezon	1	-	15.0			
Sebastes atrovirens	kelp rockfish	1	59	2.0			
Syngnathus spp.	pipefishes	2	165 - 168	0.6 - 2.0	2	197 - 210	2.0 - 6.1
Crabs							
Cancer antennarius	brown rock crab	31	21 - 77	2.0 - 104.0	11	19 - 74	1.0 - 86.0
Cancer antennarius/C. jordani	cancer crabs				1	16	1.0
Cancer anthonyi	yellow rock crab	1	49	13.5	1	34	5.8
Cancer gracilis	slender rock crab	1	31	5.4	4	10 - 41	0.3 - 10.0
Cancer jordani	hairy rock crab	5	20 - 33	1.5 - 8.5	10	12 - 22	0.6 - 3.0
Cancer productus	red rock crab	1	56	18.0			
Cancer spp.	cancer crabs				2	11	0.9 - 1.1
Loxorhynchus crispatus	moss crab				2	9 - 11	0.1 - 3.0
Pachygrapsus crassipes	striped shore crab	1	37	22.5			
Portunus xantusii	Xantus' swimming crab	5	49 - 57	13.4 - 22.0	3	52 - 54	15.0- 16.8
Pugettia producta	northern kelp crab	8	15 - 55	1.7 - 95.5	7	5 - 31	0.1 - 13.2
Pugettia richii	cryptic kelp crab				2	6 - 12	0.1 - 0.7
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	2	12	1.0			
Pandalus platyceros	spot shrimp	1	38	4.0			
Pandalus spp.	unidentified shrimp	1	20	0.2	2	16	2.7
Cephalopods							
Octopus spp.	octopus				1	16	-
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	7	0.5 - 1.0	5	8 - 17	0.1 - 1.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0051	08/24/00	08/25/00	24	24	24	24	24	24	24	24

Table H1-52. Morro Bay Power Plant Impingement Abundance Survey 52, August 31, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Hydrolagus colliei	ratfish	1	524	591.0			
Platyrhinoidis triseriata	thornback				1	370	368.0
Torpedo californica	Pacific electric ray	1	240	180.0			
Teleosts							
Atherinops affinis	topsmelt	1	66	2.4	1	82	3.9
Citharichthys stigmaeus	speckled sanddab				1	82	7.8
Cymatogaster aggregata	shiner surfperch	2	52 - 59	2.9 - 3.5	1	53	3.0
Engraulis mordax	northern anchovy	1	-	-	1	130	21.0
Leptocottus armatus	Pacific staghorn sculpin	1	90	10.8			
Osmeridae unid.	smelts				1	61	2.0
Porichthys notatus	plainfin midshipmen	1	270	213.0			
Sardinops sagax	Pacific sardine				6	184 - 192	60.0 - 82.0
Synchirus gilli	manacled sculpin	1	96	8.5			
Syngnathus leptorhynchus	bay pipefish	1	220	5.4	1	315	6.0
Syngnathus spp.	pipefishes				1	173	2.1
Crabs							
Cancer antennarius	brown rock crab	19	16 - 55	1.0 - 43.2	10	12 - 56	0.1 - 55.2
Cancer antennarius/C. jordani	cancer crabs	1	13	0.8	1	19	2.0
Cancer anthonyi	yellow rock crab				1	18	1.3
Cancer gracilis	slender rock crab				1	18	0.2
Cancer jordani	hairy rock crab	5	13 - 44	0.4 - 11.0	4	20 - 22	2.5 - 3.6
Loxorhynchus crispatus	moss crab	1	13	1.1	2	10 - 19	2.6 - 5.9
Portunus xantusii	Xantus' swimming crab				1	46	10.0
Pugettia producta	northern kelp crab	8	11 - 58	0.9 - 40.0	9	7 - 45	0.1 - 32.3
Pugettia richii	cryptic kelp crab				2	6 - 8	0.1 - 0.4
Shrimps							
Crangon nigricauda	black-tailed bay shrimp	4	9 - 13	0.9 - 2.2	1	14	2.0
Cephalopods							
Loligo opalescens	market squid	1	42	2.8			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	1	10	0.1	4	6 - 35	0.1 - 20.0

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0052	08/31/00	09/01/00	24	24	24	24	24	24	24	24

Table H1-53. Morro Bay Power Plant Impingement Abundance Survey 53, September 7, 2000.

		Units 1 and 2			Units 3 and 4		
		Count	Length Range (mm)	Weight Range (g)	Count	Length Range (mm)	Weight Range (g)
Elasmobranchs							
Platyrhinoidis triseriata	thornback				10	90 - 590	4.5 - 1473.5
Torpedo californica	Pacific electric ray	1	180	120.0			
Teleosts							
Artedius lateralis	smoothhead sculpin	1	80	8.6			
Artedius spp.	sculpins	1	63	10.0			
Atherinops affinis	topsmelt	2	80 - 109	7.1 - 10.2	1	41	3.7
Brachyistius frenatus	kelp surfperch				1	85	12.0
Citharichthys sordidus	Pacific sanddab				1	-	4.9
Citharichthys stigmaeus	speckled sanddab				2	44 - 67	4.2 - 5.0
Cymatogaster aggregata	shiner surfperch	1	54	-			
Engraulis mordax	northern anchovy				1	57	2.4
Leptocottus armatus	Pacific staghorn sculpin	1	107	22.6			
Osmeridae unid.	smelts				1	51	1.0
Porichthys notatus	plainfin midshipmen	1	246	150.0			
Sardinops sagax	Pacific sardine				6	163 - 190	54.5 - 77.5
Scorpaenichthys marmoratus	cabezon	2	67 - 370	10.2 - 996.0			
Syngnathus spp.	pipefishes	1	12	3.3	1	230	3.9
Crabs							
Cancer antennarius	brown rock crab	27	14 - 92	3.2 - 161.0	3	13 - 58	0.9 - 17.3
Cancer gracilis	slender rock crab	1	12	0.1			
Cancer jordani	hairy rock crab	5	11 - 23	0.5 - 3.5	4	12 - 21	0.5 - 3.4
Loxorhynchus crispatus	moss crab				4	9 - 53	3.0 - 99.5
Pachygrapsus crassipes	striped shore crab	1	11	2.9	1	12	1.0
Portunus xantusii	Xantus' swimming crab	1	51	15.0	3	53 - 57	19.0 - 24.8
Pugettia producta	northern kelp crab	3	14 - 32	2.0 - 11.5	4	9 - 37	0.2 - 24.9
Pugettia richii	cryptic kelp crab	1	6	-	4	6 - 13	0.2 - 3.3
Shrimps							
Crangon nigricauda	black-tailed bay shrimp				1	8	1.0
Crangon nigromaculata	spotted bay shrimp				1	17	4.5
Crangon spp.	bay shrimp				1	-	2.3
Pandalus spp.	unidentified shrimp	1	9	1.0			
Sea Urchins							
Strongylocentrotus purpuratus	purple sea urchin	2	11 - 12	0.8	5	8 - 22	0.1 - 5.7

Pump operating status (hours of operation during 24-hour sampling period):

Survey Number	Start Date	End Date	Unit 1 Pump 1	Unit 1 Pump 2	Unit 2 Pump 3	Unit 2 Pump 4	Unit 3 Pump 5	Unit 3 Pump 6	Unit 4 Pump 7	Unit 4 Pump 8
MBIAS0053	09/07/00	09/08/00	24	24	24	24	24	24	24	24

Table H2-1. Estimates of the weekly numbers and biomass of northern anchovy *Engraulis mordax* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	Survey End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	13	117.2	0.96	8.49
13-Sep-99	19-Sep-99	16,810,758	6	73.4	0.38	4.37
20-Sep-99	26-Sep-99	17,134,181	28	196.6	1.62	11.48
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	6	26.2	0.42	1.75
18-Oct-99	24-Oct-99	16,926,137	27	319.6	1.59	18.88
25-Oct-99	31-Oct-99	16,962,928	13	79.4	0.79	4.68
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	0	0.0	0.00	0.00
15-Nov-99	20-Nov-99	11,184,467	6	107.6	0.50	9.62
21-Nov-99	27-Nov-99	12,877,899	0	0.0	0.00	0.00
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	0	0.0	0.00	0.00
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	0	0.0	0.00	0.00
10-Jan-00	16-Jan-00	17,234,569	81	*	4.72	0.00
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	0	0.0	0.00	0.00
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	0	0.0	0.00	0.00
28-Feb-00	5-Mar-00	8,060,616	11	*	1.31	0.00
6-Mar-00	12-Mar-00	9,475,595	6	*	0.65	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	14	9.2	2.62	1.70
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	0	0.0	0.00	0.00
29-May-00	4-Jun-00	17,257,509	34	420.7	1.97	24.38
5-Jun-00	11-Jun-00	16,408,296	8	128.3	0.49	7.82
12-Jun-00	18-Jun-00	17,622,722	19	83.7	1.09	4.75
19-Jun-00	25-Jun-00	17,453,970	51,212	413718.0	2934.11	23703.38
26-Jun-00	2-Jul-00	17,659,970	2,303	14685.1	130.41	831.55
3-Jul-00	9-Jul-00	13,755,343	92	469.7	6.68	34.15
10-Jul-00	16-Jul-00	16,861,860	0	0.0	0.00	0.00
17-Jul-00	23-Jul-00	16,536,163	37	412.4	2.25	24.94
24-Jul-00	2-Aug-00	24,898,843	68	1013.4	2.72	40.70
3-Aug-00	13-Aug-00	27,339,851	11	12.0	0.40	0.44
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	155	2291.1	8.86	131.09
28-Aug-00	3-Sep-00	16,640,754	13	137.9	0.79	8.29
4-Sep-00	10-Sep-00	16,820,636	6	15.4	0.38	0.92
		Totals:	54,170	434,317		

* Weight unobtainable.

Table H2-2. Estimates of the weekly numbers and biomass topsmelt *Atherinops affinis* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	7	116.5	0.48	8.45
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	14	57.7	0.81	3.37
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	7	251.1	0.40	14.42
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	7	35.6	0.40	2.10
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	13	33.3	0.80	2.01
15-Nov-99	20-Nov-99	11,184,467	0	0.0	0.00	0.00
21-Nov-99	27-Nov-99	12,877,899	6	38.8	0.50	3.01
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	0	0.0	0.00	0.00
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	0	0.0	0.00	0.00
10-Jan-00	16-Jan-00	17,234,569	0	0.0	0.00	0.00
17-Jan-00	23-Jan-00	16,555,014	7	*	0.41	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	7	14.7	0.40	0.83
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	7	44.4	0.39	2.65
21-Feb-00	27-Feb-00	11,892,635	3,728	132183.7	313.49	11114.75
28-Feb-00	5-Mar-00	8,060,616	5	135.5	0.66	16.81
6-Mar-00	12-Mar-00	9,475,595	12	34.1	1.31	3.60
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	6	137.9	0.43	9.86
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	4	122.3	1.07	29.51
1-May-00	7-May-00	9,774,471	5	172.4	0.55	17.64
8-May-00	14-May-00	5,421,440	7	218.1	1.31	40.23
15-May-00	21-May-00	10,171,036	22	404.6	2.18	39.78
22-May-00	28-May-00	16,869,355	33	518.1	1.96	30.71
29-May-00	4-Jun-00	17,257,509	48	1448.7	2.76	83.94
5-Jun-00	11-Jun-00	16,408,296	0	0.0	0.00	0.00
12-Jun-00	18-Jun-00	17,622,722	10	*	0.55	0.00
19-Jun-00	25-Jun-00	17,453,970	13	335.1	0.75	19.20
26-Jun-00	2-Jul-00	17,659,970	0	0.0	0.00	0.00
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	13	101.4	0.79	6.01
17-Jul-00	23-Jul-00	16,536,163	25	101.2	1.50	6.12
24-Jul-00	2-Aug-00	24,898,843	48	556.2	1.94	22.34
3-Aug-00	13-Aug-00	27,339,851	11	13.1	0.40	0.48
14-Aug-00	20-Aug-00	17,389,693	7	49.4	0.41	2.84
21-Aug-00	27-Aug-00	17,477,023	18	204.0	1.04	11.67
28-Aug-00	3-Sep-00	16,640,754	13	41.4	0.79	2.49
4-Sep-00	10-Sep-00	16,820,636	19	135.1	1.15	8.03
		Totals:	4,124	137504.3		

* Weight unobtainable.

Table H2-3. Estimates of the weekly numbers and biomass plainfin midshipman *Porichthys notatus* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	13	16.7	0.77	1.00
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	6	96.6	0.42	6.47
18-Oct-99	24-Oct-99	16,926,137	0	0.0	0.00	0.00
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	7	*	0.40	0.00
15-Nov-99	20-Nov-99	11,184,467	0	0.0	0.00	0.00
21-Nov-99	27-Nov-99	12,877,899	6	7.1	0.50	0.55
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	7	7.3	0.52	0.52
13-Dec-99	18-Dec-99	11,732,285	12	121.5	1.02	10.36
19-Dec-99	25-Dec-99	10,784,727	5	5.8	0.48	0.53
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	8	4.0	0.46	0.23
10-Jan-00	16-Jan-00	17,234,569	0	0.0	0.00	0.00
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	0	0.0	0.00	0.00
7-Feb-00	13-Feb-00	17,704,714	7	14.0	0.40	0.79
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	0	0.0	0.00	0.00
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	7	212.5	0.66	20.72
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	11	1245.6	1.10	127.43
8-May-00	14-May-00	5,421,440	64	2426.1	11.79	447.50
15-May-00	21-May-00	10,171,036	44	2420.9	4.37	238.02
22-May-00	28-May-00	16,869,355	937	38027.7	55.56	2254.25
29-May-00	4-Jun-00	17,257,509	572	22896.8	33.14	1326.77
5-Jun-00	11-Jun-00	16,408,296	1,646	62684.3	100.31	3820.28
12-Jun-00	18-Jun-00	17,622,722	106	3488.3	6.01	197.94
19-Jun-00	25-Jun-00	17,453,970	414	14558.6	23.72	834.12
26-Jun-00	2-Jul-00	17,659,970	38	1162.8	2.13	65.84
3-Jul-00	9-Jul-00	13,755,343	8	479.3	0.56	34.85
10-Jul-00	16-Jul-00	16,861,860	13	325.4	0.79	19.30
17-Jul-00	23-Jul-00	16,536,163	0	0.0	0.00	0.00
24-Jul-00	2-Aug-00	24,898,843	0	0.0	0.00	0.00
3-Aug-00	13-Aug-00	27,339,851	0	0.0	0.00	0.00
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	0	0.0	0.00	0.00
28-Aug-00	3-Sep-00	16,640,754	7	1398.5	0.39	84.04
4-Sep-00	10-Sep-00	16,820,636	6	965.3	0.38	57.39
		Totals:	3,944	152565.1		

* Weight unobtainable.

Table H2-4. Estimates of the weekly numbers and biomass speckled sanddab *Citharichthys stigmaeus* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6\ m^3$)	Impingement Rate ($g/10^6\ m^3$)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	22	168.3	1.32	9.95
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	27	235.0	1.59	13.89
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	7	81.2	0.40	4.74
8-Nov-99	14-Nov-99	16,601,805	33	186.0	2.01	11.20
15-Nov-99	20-Nov-99	11,184,467	44	400.9	3.97	35.84
21-Nov-99	27-Nov-99	12,877,899	13	43.3	1.00	3.36
28-Nov-99	5-Dec-99	12,162,467	16	15.2	1.31	1.25
6-Dec-99	12-Dec-99	14,173,408	7	36.6	0.52	2.58
13-Dec-99	18-Dec-99	11,732,285	54	385.5	4.59	32.86
19-Dec-99	25-Dec-99	10,784,727	10	54.9	0.97	5.09
26-Dec-99	1-Jan-00	13,040,517	26	155.7	1.97	11.94
2-Jan-00	9-Jan-00	17,329,512	24	122.7	1.39	7.08
10-Jan-00	16-Jan-00	17,234,569	7	3.4	0.39	0.20
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	21	29.3	1.19	1.66
7-Feb-00	13-Feb-00	17,704,714	42	55.4	2.37	3.13
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	123	489.5	10.35	41.16
28-Feb-00	5-Mar-00	8,060,616	5	4.8	0.66	0.59
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	28	29.2	1.76	1.82
3-Apr-00	9-Apr-00	13,993,977	24	36.4	1.71	2.60
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	4	2.7	1.07	0.64
1-May-00	7-May-00	9,774,471	65	244.6	6.61	25.02
8-May-00	14-May-00	5,421,440	107	125.0	19.66	23.06
15-May-00	21-May-00	10,171,036	255	427.3	25.10	42.02
22-May-00	28-May-00	16,869,355	238	489.1	14.09	28.99
29-May-00	4-Jun-00	17,257,509	579	1483.8	33.53	85.98
5-Jun-00	11-Jun-00	16,408,296	40	100.0	2.46	6.10
12-Jun-00	18-Jun-00	17,622,722	164	531.3	9.29	30.15
19-Jun-00	25-Jun-00	17,453,970	13	71.0	0.75	4.07
26-Jun-00	2-Jul-00	17,659,970	75	297.9	4.25	16.87
3-Jul-00	9-Jul-00	13,755,343	23	119.4	1.67	8.68
10-Jul-00	16-Jul-00	16,861,860	47	136.7	2.77	8.11
17-Jul-00	23-Jul-00	16,536,163	12	57.1	0.75	3.46
24-Jul-00	2-Aug-00	24,898,843	135	681.0	5.44	27.35
3-Aug-00	13-Aug-00	27,339,851	0	0.0	0.00	0.00
14-Aug-00	20-Aug-00	17,389,693	7	51.6	0.41	2.97
21-Aug-00	27-Aug-00	17,477,023	27	164.8	1.56	9.43
28-Aug-00	3-Sep-00	16,640,754	7	51.2	0.39	3.08
4-Sep-00	10-Sep-00	16,820,636	13	59.2	0.77	3.52
		Totals:	2,345	7627.0		

Table H2-5. Estimates of the weekly numbers and biomass Pacific sardine *Sardinops sagax* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	13	468.7	0.96	33.97
13-Sep-99	19-Sep-99	16,810,758	6	130.7	0.38	7.77
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	7	227.1	0.44	13.43
4-Oct-99	10-Oct-99	17,417,176	41	1820.6	2.38	104.53
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	20	987.8	1.19	58.36
25-Oct-99	31-Oct-99	16,962,928	13	287.8	0.79	16.97
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	27	1422.0	1.61	85.66
15-Nov-99	20-Nov-99	11,184,467	11	467.4	0.99	41.79
21-Nov-99	27-Nov-99	12,877,899	13	840.3	1.00	65.25
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	0	0.0	0.00	0.00
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	8	653.7	0.46	37.72
10-Jan-00	16-Jan-00	17,234,569	0	0.0	0.00	0.00
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	0	0.0	0.00	0.00
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	7	446.9	0.39	26.70
21-Feb-00	27-Feb-00	11,892,635	0	0.0	0.00	0.00
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	0	0.0	0.00	0.00
29-May-00	4-Jun-00	17,257,509	0	0.0	0.00	0.00
5-Jun-00	11-Jun-00	16,408,296	0	0.0	0.00	0.00
12-Jun-00	18-Jun-00	17,622,722	0	0.0	0.00	0.00
19-Jun-00	25-Jun-00	17,453,970	26	958.0	1.51	54.89
26-Jun-00	2-Jul-00	17,659,970	0	0.0	0.00	0.00
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	0	0.0	0.00	0.00
17-Jul-00	23-Jul-00	16,536,163	31	2510.5	1.88	151.82
24-Jul-00	2-Aug-00	24,898,843	58	4888.5	2.33	196.34
3-Aug-00	13-Aug-00	27,339,851	44	3270.7	1.59	119.63
14-Aug-00	20-Aug-00	17,389,693	7	534.6	0.41	30.74
21-Aug-00	27-Aug-00	17,477,023	9	779.5	0.52	44.60
28-Aug-00	3-Sep-00	16,640,754	39	2281.6	2.37	137.11
4-Sep-00	10-Sep-00	16,820,636	39	1395.8	2.30	82.98
		Totals:	421	24372.4		

Table H2-6. Estimates of the weekly numbers and biomass cabezon *Scorpaenichthys marmoratus* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	20	341.6	1.44	24.76
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	7	833.8	0.41	48.66
27-Sep-99	3-Oct-99	16,915,689	15	276.3	0.88	16.33
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	12	1150.7	0.84	77.12
18-Oct-99	24-Oct-99	16,926,137	0	0.0	0.00	0.00
25-Oct-99	31-Oct-99	16,962,928	13	860.8	0.79	50.75
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	7	328.7	0.40	19.80
15-Nov-99	20-Nov-99	11,184,467	6	200.1	0.50	17.90
21-Nov-99	27-Nov-99	12,877,899	0	0.0	0.00	0.00
28-Nov-99	5-Dec-99	12,162,467	8	918.6	0.66	75.53
6-Dec-99	12-Dec-99	14,173,408	7	192.6	0.52	13.59
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	5	170.4	0.48	15.80
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	16	1271.4	0.93	73.37
10-Jan-00	16-Jan-00	17,234,569	14	614.4	0.79	35.65
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	7	471.3	0.40	26.69
31-Jan-00	6-Feb-00	17,683,818	7	524.7	0.40	29.67
7-Feb-00	13-Feb-00	17,704,714	7	*	0.40	0.00
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	18	694.6	1.48	58.41
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	11	1365.2	1.10	139.67
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	0	0.0	0.00	0.00
29-May-00	4-Jun-00	17,257,509	7	11.6	0.39	0.67
5-Jun-00	11-Jun-00	16,408,296	8	6269.2	0.49	382.07
12-Jun-00	18-Jun-00	17,622,722	10	22.1	0.55	1.26
19-Jun-00	25-Jun-00	17,453,970	7	65.7	0.38	3.76
26-Jun-00	2-Jul-00	17,659,970	50	190.3	2.84	10.77
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	20	97.4	1.19	5.77
17-Jul-00	23-Jul-00	16,536,163	6	83.2	0.38	5.03
24-Jul-00	2-Aug-00	24,898,843	29	85.1	1.17	3.42
3-Aug-00	13-Aug-00	27,339,851	11	46.8	0.40	1.71
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	9	136.6	0.52	7.82
28-Aug-00	3-Sep-00	16,640,754	0	0.0	0.00	0.00
4-Sep-00	10-Sep-00	16,820,636	13	6475.3	0.77	384.96
		Totals:	349	23698.5		

* Weight unobtainable.

Table H2-7. Estimates of the weekly numbers and biomass rockfishes Scorpaenidae impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6\ m^3$)	Impingement Rate ($g/10^6\ m^3$)
6-Sep-99	12-Sep-99	13,796,838	26	791.8	1.92	57.39
13-Sep-99	19-Sep-99	16,810,758	13	106.2	0.77	6.32
20-Sep-99	26-Sep-99	17,134,181	7	2292.9	0.41	133.82
27-Sep-99	3-Oct-99	16,915,689	7	14.9	0.44	0.88
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	6	0.0	0.42	0.00
18-Oct-99	24-Oct-99	16,926,137	7	492.2	0.40	29.08
25-Oct-99	31-Oct-99	16,962,928	27	43.0	1.59	2.54
1-Nov-99	7-Nov-99	17,119,645	20	281.2	1.20	16.43
8-Nov-99	14-Nov-99	16,601,805	20	350.0	1.20	21.08
15-Nov-99	20-Nov-99	11,184,467	0	0.0	0.00	0.00
21-Nov-99	27-Nov-99	12,877,899	39	481.6	3.01	37.39
28-Nov-99	5-Dec-99	12,162,467	40	500.0	3.28	41.11
6-Dec-99	12-Dec-99	14,173,408	22	284.1	1.55	20.04
13-Dec-99	18-Dec-99	11,732,285	6	58.1	0.51	4.95
19-Dec-99	25-Dec-99	10,784,727	0	0.0	0.00	0.00
26-Dec-99	1-Jan-00	13,040,517	6	495.4	0.49	37.99
2-Jan-00	9-Jan-00	17,329,512	16	341.7	0.93	19.72
10-Jan-00	16-Jan-00	17,234,569	0	0.0	0.00	0.00
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	0	0.0	0.00	0.00
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	12	225.7	0.99	18.98
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	6	136.4	0.65	14.39
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	6	75.8	0.43	5.42
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	4	630.6	1.07	152.13
1-May-00	7-May-00	9,774,471	5	0.0	0.55	0.00
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	7	6.6	0.39	0.39
29-May-00	4-Jun-00	17,257,509	20	122.5	1.18	7.10
5-Jun-00	11-Jun-00	16,408,296	8	227.5	0.49	13.87
12-Jun-00	18-Jun-00	17,622,722	10	6.7	0.55	0.38
19-Jun-00	25-Jun-00	17,453,970	13	212.2	0.75	12.16
26-Jun-00	2-Jul-00	17,659,970	25	33.8	1.42	1.91
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	7	4.0	0.40	0.24
17-Jul-00	23-Jul-00	16,536,163	12	1069.5	0.75	64.68
24-Jul-00	2-Aug-00	24,898,843	29	94.8	1.17	3.81
3-Aug-00	13-Aug-00	27,339,851	11	81.6	0.40	2.98
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	9	18.2	0.52	1.04
28-Aug-00	3-Sep-00	16,640,754	0	0.0	0.00	0.00
4-Sep-00	10-Sep-00	16,820,636	0	0.0	0.00	0.00
		Totals:	448	9479.1		

Table H2-8. Estimates of the weekly numbers and biomass market squid *Loligo opalescens* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	13	68.2	0.96	4.94
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	7	282.7	0.40	16.70
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	0	0.0	0.00	0.00
15-Nov-99	20-Nov-99	11,184,467	0	0.0	0.00	0.00
21-Nov-99	27-Nov-99	12,877,899	6	86.0	0.50	6.68
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	0	0.0	0.00	0.00
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	0	0.0	0.00	0.00
10-Jan-00	16-Jan-00	17,234,569	0	0.0	0.00	0.00
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	0	0.0	0.00	0.00
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	13	92.8	0.78	5.54
21-Feb-00	27-Feb-00	11,892,635	0	0.0	0.00	0.00
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	12	50.2	0.85	3.58
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	7	130.7	0.39	7.75
29-May-00	4-Jun-00	17,257,509	34	213.8	1.97	12.39
5-Jun-00	11-Jun-00	16,408,296	113	448.6	6.88	27.34
12-Jun-00	18-Jun-00	17,622,722	154	450.5	8.74	25.56
19-Jun-00	25-Jun-00	17,453,970	16,368	35789.6	937.76	2050.51
26-Jun-00	2-Jul-00	17,659,970	25	63.8	1.42	3.61
3-Jul-00	9-Jul-00	13,755,343	15	160.8	1.11	11.69
10-Jul-00	16-Jul-00	16,861,860	0	0.0	0.00	0.00
17-Jul-00	23-Jul-00	16,536,163	12	75.2	0.75	4.54
24-Jul-00	2-Aug-00	24,898,843	10	*	0.39	0.00
3-Aug-00	13-Aug-00	27,339,851	11	23.9	0.40	0.88
14-Aug-00	20-Aug-00	17,389,693	7	81.7	0.41	4.70
21-Aug-00	27-Aug-00	17,477,023	0	0.0	0.00	0.00
28-Aug-00	3-Sep-00	16,640,754	7	18.4	0.39	1.10
4-Sep-00	10-Sep-00	16,820,636	0	0.0	0.00	0.00
		Totals:	16,814	38036.7		

* Weight unobtainable.

Table H2-9. Estimates of the weekly numbers and biomass black-tailed bay shrimp *Crangon nigricauda* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6\ m^3$)	Impingement Rate ($g/10^6\ m^3$)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	13	38.6	0.77	2.30
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	7	7.4	0.44	0.44
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	6	3.7	0.42	0.25
18-Oct-99	24-Oct-99	16,926,137	0	0.0	0.00	0.00
25-Oct-99	31-Oct-99	16,962,928	13	12.1	0.79	0.71
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	0	0.0	0.00	0.00
15-Nov-99	20-Nov-99	11,184,467	6	6.7	0.50	0.59
21-Nov-99	27-Nov-99	12,877,899	0	0.0	0.00	0.00
28-Nov-99	5-Dec-99	12,162,467	8	25.5	0.66	2.10
6-Dec-99	12-Dec-99	14,173,408	22	29.3	1.55	2.07
13-Dec-99	18-Dec-99	11,732,285	60	111.7	5.10	9.52
19-Dec-99	25-Dec-99	10,784,727	5	1.0	0.48	0.10
26-Dec-99	1-Jan-00	13,040,517	39	56.6	2.96	4.34
2-Jan-00	9-Jan-00	17,329,512	24	69.8	1.39	4.03
10-Jan-00	16-Jan-00	17,234,569	88	136.3	5.12	7.91
17-Jan-00	23-Jan-00	16,555,014	34	70.0	2.05	4.23
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	77	81.7	4.35	4.62
7-Feb-00	13-Feb-00	17,704,714	56	157.7	3.17	8.91
14-Feb-00	20-Feb-00	16,737,624	13	15.7	0.78	0.94
21-Feb-00	27-Feb-00	11,892,635	873	1849.4	73.44	155.51
28-Feb-00	5-Mar-00	8,060,616	16	30.7	1.97	3.81
6-Mar-00	12-Mar-00	9,475,595	68	63.2	7.20	6.67
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	40	63.2	3.93	6.16
25-Mar-00	2-Apr-00	16,024,015	9	10.4	0.59	0.65
3-Apr-00	9-Apr-00	13,993,977	84	148.1	5.97	10.58
10-Apr-00	16-Apr-00	8,110,119	35	113.5	4.37	14.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	18	13.7	4.28	3.31
1-May-00	7-May-00	9,774,471	119	359.9	12.13	36.82
8-May-00	14-May-00	5,421,440	21	32.0	3.93	5.90
15-May-00	21-May-00	10,171,036	333	623.4	32.74	61.29
22-May-00	28-May-00	16,869,355	218	636.3	12.91	37.72
29-May-00	4-Jun-00	17,257,509	3,860	6717.7	223.67	389.26
5-Jun-00	11-Jun-00	16,408,296	315	619.7	19.18	37.76
12-Jun-00	18-Jun-00	17,622,722	510	929.0	28.95	52.72
19-Jun-00	25-Jun-00	17,453,970	105	306.2	6.02	17.54
26-Jun-00	2-Jul-00	17,659,970	75	154.0	4.25	8.72
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	73	206.7	4.35	12.26
17-Jul-00	23-Jul-00	16,536,163	43	93.8	2.63	5.67
24-Jul-00	2-Aug-00	24,898,843	135	327.9	5.44	13.17
3-Aug-00	13-Aug-00	27,339,851	22	26.1	0.80	0.95
14-Aug-00	20-Aug-00	17,389,693	21	56.6	1.24	3.26
21-Aug-00	27-Aug-00	17,477,023	18	18.2	1.04	1.04
28-Aug-00	3-Sep-00	16,640,754	33	49.2	1.97	2.96
4-Sep-00	10-Sep-00	16,820,636	6	6.4	0.38	0.38
		Totals:	7,524	14279.3		

Table H2-10. Estimates of the weekly numbers and biomass Xantus' swimming crab *Portunus xantusii* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6 m^3$)	Impingement Rate ($g/10^6 m^3$)
6-Sep-99	12-Sep-99	13,796,838	225	2338.3	16.31	169.48
13-Sep-99	19-Sep-99	16,810,758	380	5313.3	22.59	316.07
20-Sep-99	26-Sep-99	17,134,181	604	6643.2	35.28	387.72
27-Sep-99	3-Oct-99	16,915,689	164	1574.9	9.68	93.10
4-Oct-99	10-Oct-99	17,417,176	248	2887.3	14.26	165.78
11-Oct-99	17-Oct-99	14,921,089	50	543.3	3.34	36.41
18-Oct-99	24-Oct-99	16,926,137	60	1517.0	3.57	89.62
25-Oct-99	31-Oct-99	16,962,928	13	340.3	0.79	20.06
1-Nov-99	7-Nov-99	17,119,645	61	1336.5	3.59	78.07
8-Nov-99	14-Nov-99	16,601,805	87	1560.7	5.22	94.01
15-Nov-99	20-Nov-99	11,184,467	50	972.5	4.46	86.95
21-Nov-99	27-Nov-99	12,877,899	123	2679.7	9.54	208.09
28-Nov-99	5-Dec-99	12,162,467	48	1014.3	3.93	83.40
6-Dec-99	12-Dec-99	14,173,408	110	2664.1	7.75	187.97
13-Dec-99	18-Dec-99	11,732,285	287	7572.3	24.49	645.42
19-Dec-99	25-Dec-99	10,784,727	110	2970.9	10.18	275.47
26-Dec-99	1-Jan-00	13,040,517	116	2631.2	8.88	201.77
2-Jan-00	9-Jan-00	17,329,512	56	1410.2	3.24	81.37
10-Jan-00	16-Jan-00	17,234,569	312	7296.2	18.10	423.35
17-Jan-00	23-Jan-00	16,555,014	68	1677.8	4.10	101.34
24-Jan-00	30-Jan-00	17,657,018	84	2048.5	4.78	116.02
31-Jan-00	6-Feb-00	17,683,818	119	3121.3	6.72	176.51
7-Feb-00	13-Feb-00	17,704,714	77	2294.4	4.35	129.59
14-Feb-00	20-Feb-00	16,737,624	314	7391.2	18.74	441.59
21-Feb-00	27-Feb-00	11,892,635	299	6519.0	25.14	548.16
28-Feb-00	5-Mar-00	8,060,616	64	1055.8	7.88	130.98
6-Mar-00	12-Mar-00	9,475,595	19	336.6	1.96	35.53
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	20	517.0	1.97	50.42
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	14	348.1	2.62	64.21
15-May-00	21-May-00	10,171,036	6	112.1	0.55	11.02
22-May-00	28-May-00	16,869,355	33	508.9	1.96	30.17
29-May-00	4-Jun-00	17,257,509	34	599.8	1.97	34.75
5-Jun-00	11-Jun-00	16,408,296	32	749.6	1.97	45.68
12-Jun-00	18-Jun-00	17,622,722	48	1277.3	2.73	72.48
19-Jun-00	25-Jun-00	17,453,970	39	928.4	2.26	53.19
26-Jun-00	2-Jul-00	17,659,970	13	*	0.71	0.00
3-Jul-00	9-Jul-00	13,755,343	69	1245.0	5.01	90.51
10-Jul-00	16-Jul-00	16,861,860	73	1420.4	4.35	84.24
17-Jul-00	23-Jul-00	16,536,163	50	842.8	3.00	50.97
24-Jul-00	2-Aug-00	24,898,843	48	698.4	1.94	28.05
3-Aug-00	13-Aug-00	27,339,851	87	1755.5	3.18	64.21
14-Aug-00	20-Aug-00	17,389,693	14	198.5	0.82	11.41
21-Aug-00	27-Aug-00	17,477,023	73	1213.9	4.17	69.45
28-Aug-00	3-Sep-00	16,640,754	7	65.7	0.39	3.95
4-Sep-00	10-Sep-00	16,820,636	26	516.1	1.53	30.68
		Totals:	4,834	90708.3		

* Weight unobtainable.

Table H2-11. Estimates of the weekly numbers and biomass hairy rock crab *Cancer jordani* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6\ m^3$)	Impingement Rate ($g/10^6\ m^3$)
6-Sep-99	12-Sep-99	13,796,838	33	135.1	2.40	9.79
13-Sep-99	19-Sep-99	16,810,758	71	326.4	4.21	19.41
20-Sep-99	26-Sep-99	17,134,181	76	190.4	4.46	11.11
27-Sep-99	3-Oct-99	16,915,689	30	88.6	1.76	5.24
4-Oct-99	10-Oct-99	17,417,176	14	14.5	0.79	0.83
11-Oct-99	17-Oct-99	14,921,089	6	31.2	0.42	2.09
18-Oct-99	24-Oct-99	16,926,137	54	118.9	3.17	7.02
25-Oct-99	31-Oct-99	16,962,928	40	290.5	2.38	17.13
1-Nov-99	7-Nov-99	17,119,645	48	77.1	2.79	4.51
8-Nov-99	14-Nov-99	16,601,805	27	284.7	1.61	17.15
15-Nov-99	20-Nov-99	11,184,467	6	13.3	0.50	1.19
21-Nov-99	27-Nov-99	12,877,899	149	1602.6	11.54	124.45
28-Nov-99	5-Dec-99	12,162,467	64	82.9	5.25	6.82
6-Dec-99	12-Dec-99	14,173,408	132	303.1	9.30	21.39
13-Dec-99	18-Dec-99	11,732,285	108	195.1	9.18	16.63
19-Dec-99	25-Dec-99	10,784,727	146	356.8	13.57	33.08
26-Dec-99	1-Jan-00	13,040,517	51	178.5	3.95	13.69
2-Jan-00	9-Jan-00	17,329,512	144	1848.9	8.33	106.69
10-Jan-00	16-Jan-00	17,234,569	109	522.2	6.30	30.30
17-Jan-00	23-Jan-00	16,555,014	75	827.7	4.52	49.99
24-Jan-00	30-Jan-00	17,657,018	106	694.3	5.98	39.32
31-Jan-00	6-Feb-00	17,683,818	112	211.0	6.32	11.93
7-Feb-00	13-Feb-00	17,704,714	42	119.1	2.37	6.73
14-Feb-00	20-Feb-00	16,737,624	150	368.5	8.98	22.02
21-Feb-00	27-Feb-00	11,892,635	123	407.7	10.35	34.28
28-Feb-00	5-Mar-00	8,060,616	48	87.3	5.91	10.83
6-Mar-00	12-Mar-00	9,475,595	25	26.0	2.62	2.75
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	87	149.9	8.52	14.62
25-Mar-00	2-Apr-00	16,024,015	47	25.4	2.94	1.59
3-Apr-00	9-Apr-00	13,993,977	72	113.7	5.12	8.13
10-Apr-00	16-Apr-00	8,110,119	9	25.7	1.09	3.17
17-Apr-00	23-Apr-00	4,969,914	18	33.1	3.70	6.66
24-Apr-00	30-Apr-00	4,145,001	44	97.0	10.69	23.41
1-May-00	7-May-00	9,774,471	43	118.8	4.41	12.15
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	55	203.1	5.46	19.97
22-May-00	28-May-00	16,869,355	33	64.0	1.96	3.80
29-May-00	4-Jun-00	17,257,509	95	140.2	5.52	8.13
5-Jun-00	11-Jun-00	16,408,296	89	324.4	5.41	19.77
12-Jun-00	18-Jun-00	17,622,722	106	133.4	6.01	7.57
19-Jun-00	25-Jun-00	17,453,970	33	88.7	1.88	5.08
26-Jun-00	2-Jul-00	17,659,970	125	389.3	7.09	22.04
3-Jul-00	9-Jul-00	13,755,343	38	75.0	2.78	5.46
10-Jul-00	16-Jul-00	16,861,860	47	120.7	2.77	7.16
17-Jul-00	23-Jul-00	16,536,163	99	273.9	6.01	16.56
24-Jul-00	2-Aug-00	24,898,843	193	503.9	7.77	20.24
3-Aug-00	13-Aug-00	27,339,851	294	1003.9	10.74	36.72
14-Aug-00	20-Aug-00	17,389,693	129	345.4	7.42	19.86
21-Aug-00	27-Aug-00	17,477,023	137	316.9	7.82	18.13
28-Aug-00	3-Sep-00	16,640,754	59	229.1	3.55	13.77
4-Sep-00	10-Sep-00	16,820,636	58	137.7	3.44	8.19
		Totals:	3,898	14316.2		

Table H2-12. Estimates of the weekly numbers and biomass brown rock crab *Cancer antennarius* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	53	4939.4	3.84	358.01
13-Sep-99	19-Sep-99	16,810,758	6	479.6	0.38	28.53
20-Sep-99	26-Sep-99	17,134,181	28	1383.4	1.62	80.74
27-Sep-99	3-Oct-99	16,915,689	60	2757.4	3.52	163.01
4-Oct-99	10-Oct-99	17,417,176	21	1509.4	1.19	86.66
11-Oct-99	17-Oct-99	14,921,089	44	3911.3	2.92	262.13
18-Oct-99	24-Oct-99	16,926,137	27	585.6	1.59	34.60
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	27	390.5	1.59	22.81
8-Nov-99	14-Nov-99	16,601,805	67	3999.4	4.02	240.90
15-Nov-99	20-Nov-99	11,184,467	17	154.1	1.49	13.78
21-Nov-99	27-Nov-99	12,877,899	0	0.0	0.00	0.00
28-Nov-99	5-Dec-99	12,162,467	8	59.0	0.66	4.85
6-Dec-99	12-Dec-99	14,173,408	15	563.0	1.03	39.73
13-Dec-99	18-Dec-99	11,732,285	12	372.3	1.02	31.73
19-Dec-99	25-Dec-99	10,784,727	10	723.5	0.97	67.09
26-Dec-99	1-Jan-00	13,040,517	26	239.3	1.97	18.35
2-Jan-00	9-Jan-00	17,329,512	32	2312.6	1.85	133.45
10-Jan-00	16-Jan-00	17,234,569	20	1034.9	1.18	60.05
17-Jan-00	23-Jan-00	16,555,014	14	495.4	0.82	29.92
24-Jan-00	30-Jan-00	17,657,018	7	80.9	0.40	4.58
31-Jan-00	6-Feb-00	17,683,818	28	109.0	1.58	6.16
7-Feb-00	13-Feb-00	17,704,714	35	329.7	1.98	18.62
14-Feb-00	20-Feb-00	16,737,624	20	483.5	1.17	28.89
21-Feb-00	27-Feb-00	11,892,635	18	656.5	1.48	55.20
28-Feb-00	5-Mar-00	8,060,616	11	75.2	1.31	9.32
6-Mar-00	12-Mar-00	9,475,595	31	291.4	3.27	30.75
13-Mar-00	17-Mar-00	3,815,676	10	115.6	2.62	30.29
18-Mar-00	24-Mar-00	10,254,629	20	925.8	1.97	90.28
25-Mar-00	2-Apr-00	16,024,015	66	710.8	4.11	44.36
3-Apr-00	9-Apr-00	13,993,977	185	669.6	13.23	47.85
10-Apr-00	16-Apr-00	8,110,119	27	140.1	3.28	17.28
17-Apr-00	23-Apr-00	4,969,914	14	192.3	2.78	38.69
24-Apr-00	30-Apr-00	4,145,001	18	119.6	4.28	28.87
1-May-00	7-May-00	9,774,471	32	314.1	3.31	32.13
8-May-00	14-May-00	5,421,440	14	174.1	2.62	32.10
15-May-00	21-May-00	10,171,036	44	241.1	4.37	23.71
22-May-00	28-May-00	16,869,355	40	106.3	2.35	6.30
29-May-00	4-Jun-00	17,257,509	102	933.3	5.92	54.08
5-Jun-00	11-Jun-00	16,408,296	73	844.8	4.43	51.48
12-Jun-00	18-Jun-00	17,622,722	48	226.2	2.73	12.84
19-Jun-00	25-Jun-00	17,453,970	79	758.9	4.52	43.48
26-Jun-00	2-Jul-00	17,659,970	488	8078.4	27.64	457.44
3-Jul-00	9-Jul-00	13,755,343	214	3368.5	15.59	244.88
10-Jul-00	16-Jul-00	16,861,860	240	4010.5	14.24	237.85
17-Jul-00	23-Jul-00	16,536,163	87	1781.9	5.26	107.76
24-Jul-00	2-Aug-00	24,898,843	184	5263.7	7.38	211.40
3-Aug-00	13-Aug-00	27,339,851	337	6231.5	12.33	227.93
14-Aug-00	20-Aug-00	17,389,693	172	3647.6	9.89	209.75
21-Aug-00	27-Aug-00	17,477,023	382	5695.2	21.88	325.87
28-Aug-00	3-Sep-00	16,640,754	190	2519.3	11.44	151.39
4-Sep-00	10-Sep-00	16,820,636	193	7304.6	11.48	434.27
		Totals:	3,894	82310.1		

Table H2-13. Estimates of the weekly numbers and biomass cryptic kelp crab *Pugettia richii* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6 m^3$)	Impingement Rate ($g/10^6 m^3$)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	14	11.8	0.81	0.69
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	7	12.1	0.40	0.71
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	13	12.0	0.80	0.72
15-Nov-99	20-Nov-99	11,184,467	6	6.1	0.50	0.55
21-Nov-99	27-Nov-99	12,877,899	26	16.2	2.01	1.25
28-Nov-99	5-Dec-99	12,162,467	8	12.8	0.66	1.05
6-Dec-99	12-Dec-99	14,173,408	37	33.7	2.58	2.38
13-Dec-99	18-Dec-99	11,732,285	18	10.8	1.53	0.92
19-Dec-99	25-Dec-99	10,784,727	31	32.4	2.91	3.01
26-Dec-99	1-Jan-00	13,040,517	6	13.5	0.49	1.04
2-Jan-00	9-Jan-00	17,329,512	16	16.0	0.93	0.93
10-Jan-00	16-Jan-00	17,234,569	14	21.0	0.79	1.22
17-Jan-00	23-Jan-00	16,555,014	7	6.8	0.41	0.41
24-Jan-00	30-Jan-00	17,657,018	28	21.1	1.59	1.20
31-Jan-00	6-Feb-00	17,683,818	7	7.0	0.40	0.40
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	13	4.6	0.78	0.27
21-Feb-00	27-Feb-00	11,892,635	18	28.7	1.48	2.42
28-Feb-00	5-Mar-00	8,060,616	21	14.8	2.63	1.84
6-Mar-00	12-Mar-00	9,475,595	0	0.0	0.00	0.00
13-Mar-00	17-Mar-00	3,815,676	15	5.0	3.93	1.31
18-Mar-00	24-Mar-00	10,254,629	27	35.0	2.62	3.41
25-Mar-00	2-Apr-00	16,024,015	38	29.2	2.35	1.82
3-Apr-00	9-Apr-00	13,993,977	18	8.4	1.28	0.60
10-Apr-00	16-Apr-00	8,110,119	27	20.4	3.28	2.52
17-Apr-00	23-Apr-00	4,969,914	5	0.5	0.93	0.09
24-Apr-00	30-Apr-00	4,145,001	27	4.0	6.41	0.96
1-May-00	7-May-00	9,774,471	38	51.4	3.86	5.26
8-May-00	14-May-00	5,421,440	21	7.8	3.93	1.44
15-May-00	21-May-00	10,171,036	44	53.6	4.37	5.27
22-May-00	28-May-00	16,869,355	73	21.1	4.30	1.25
29-May-00	4-Jun-00	17,257,509	34	25.2	1.97	1.46
5-Jun-00	11-Jun-00	16,408,296	32	107.3	1.97	6.54
12-Jun-00	18-Jun-00	17,622,722	10	6.7	0.55	0.38
19-Jun-00	25-Jun-00	17,453,970	26	27.6	1.51	1.58
26-Jun-00	2-Jul-00	17,659,970	38	60.1	2.13	3.40
3-Jul-00	9-Jul-00	13,755,343	69	52.8	5.01	3.84
10-Jul-00	16-Jul-00	16,861,860	20	34.7	1.19	2.06
17-Jul-00	23-Jul-00	16,536,163	56	190.1	3.38	11.49
24-Jul-00	2-Aug-00	24,898,843	77	110.3	3.11	4.43
3-Aug-00	13-Aug-00	27,339,851	44	69.6	1.59	2.55
14-Aug-00	20-Aug-00	17,389,693	21	66.6	1.24	3.83
21-Aug-00	27-Aug-00	17,477,023	18	7.3	1.04	0.42
28-Aug-00	3-Sep-00	16,640,754	13	3.3	0.79	0.20
4-Sep-00	10-Sep-00	16,820,636	32	24.5	1.91	1.45
		Totals:	1,111	1303.7		

Table H2-14. Estimates of the weekly numbers and biomass northern kelp crab *Pugettia producta* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	73	1112.2	5.28	80.61
13-Sep-99	19-Sep-99	16,810,758	71	1365.3	4.21	81.22
20-Sep-99	26-Sep-99	17,134,181	21	98.0	1.22	5.72
27-Sep-99	3-Oct-99	16,915,689	52	743.1	3.08	43.93
4-Oct-99	10-Oct-99	17,417,176	28	191.8	1.58	11.01
11-Oct-99	17-Oct-99	14,921,089	19	31.8	1.25	2.13
18-Oct-99	24-Oct-99	16,926,137	20	566.8	1.19	33.49
25-Oct-99	31-Oct-99	16,962,928	13	14.8	0.79	0.87
1-Nov-99	7-Nov-99	17,119,645	34	360.4	1.99	21.05
8-Nov-99	14-Nov-99	16,601,805	20	60.0	1.20	3.61
15-Nov-99	20-Nov-99	11,184,467	28	33.8	2.48	3.02
21-Nov-99	27-Nov-99	12,877,899	78	204.3	6.02	15.86
28-Nov-99	5-Dec-99	12,162,467	48	1313.4	3.93	107.99
6-Dec-99	12-Dec-99	14,173,408	29	568.2	2.07	40.09
13-Dec-99	18-Dec-99	11,732,285	24	132.9	2.04	11.33
19-Dec-99	25-Dec-99	10,784,727	73	1305.6	6.79	121.06
26-Dec-99	1-Jan-00	13,040,517	6	14.8	0.49	1.13
2-Jan-00	9-Jan-00	17,329,512	56	534.2	3.24	30.83
10-Jan-00	16-Jan-00	17,234,569	14	33.2	0.79	1.93
17-Jan-00	23-Jan-00	16,555,014	48	277.2	2.87	16.75
24-Jan-00	30-Jan-00	17,657,018	21	71.8	1.20	4.06
31-Jan-00	6-Feb-00	17,683,818	49	149.5	2.77	8.46
7-Feb-00	13-Feb-00	17,704,714	42	65.9	2.37	3.72
14-Feb-00	20-Feb-00	16,737,624	33	448.9	1.95	26.82
21-Feb-00	27-Feb-00	11,892,635	18	56.9	1.48	4.78
28-Feb-00	5-Mar-00	8,060,616	11	18.0	1.31	2.23
6-Mar-00	12-Mar-00	9,475,595	43	392.4	4.58	41.42
13-Mar-00	17-Mar-00	3,815,676	10	15.5	2.62	4.07
18-Mar-00	24-Mar-00	10,254,629	74	1045.5	7.21	101.95
25-Mar-00	2-Apr-00	16,024,015	38	21.7	2.35	1.35
3-Apr-00	9-Apr-00	13,993,977	54	32.8	3.84	2.35
10-Apr-00	16-Apr-00	8,110,119	62	709.5	7.66	87.49
17-Apr-00	23-Apr-00	4,969,914	14	3.7	2.78	0.74
24-Apr-00	30-Apr-00	4,145,001	13	12.9	3.21	3.10
1-May-00	7-May-00	9,774,471	124	367.7	12.68	37.62
8-May-00	14-May-00	5,421,440	57	60.4	10.48	11.14
15-May-00	21-May-00	10,171,036	78	78.8	7.64	7.75
22-May-00	28-May-00	16,869,355	99	351.8	5.87	20.85
29-May-00	4-Jun-00	17,257,509	163	1458.5	9.47	84.52
5-Jun-00	11-Jun-00	16,408,296	56	85.5	3.44	5.21
12-Jun-00	18-Jun-00	17,622,722	19	463.0	1.09	26.27
19-Jun-00	25-Jun-00	17,453,970	72	934.4	4.14	53.53
26-Jun-00	2-Jul-00	17,659,970	200	1731.1	11.34	98.02
3-Jul-00	9-Jul-00	13,755,343	100	359.9	7.24	26.16
10-Jul-00	16-Jul-00	16,861,860	147	744.8	8.70	44.17
17-Jul-00	23-Jul-00	16,536,163	112	1362.3	6.76	82.38
24-Jul-00	2-Aug-00	24,898,843	193	1798.1	7.77	72.22
3-Aug-00	13-Aug-00	27,339,851	174	2221.1	6.37	81.24
14-Aug-00	20-Aug-00	17,389,693	86	983.9	4.95	56.58
21-Aug-00	27-Aug-00	17,477,023	137	1887.7	7.82	108.01
28-Aug-00	3-Sep-00	16,640,754	112	773.5	6.71	46.48
4-Sep-00	10-Sep-00	16,820,636	45	377.8	2.68	22.46
		Totals:	3,209	28046.9		

Table H2-15. Estimates of the weekly numbers and biomass brown shrimp *Peneaus californiensis* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	0	0.0	0.00	0.00
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	0	0.0	0.00	0.00
15-Nov-99	20-Nov-99	11,184,467	6	295.5	0.50	26.42
21-Nov-99	27-Nov-99	12,877,899	32	1597.3	2.51	124.03
28-Nov-99	5-Dec-99	12,162,467	8	254.4	0.66	20.92
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	220	7029.5	20.36	651.80
26-Dec-99	1-Jan-00	13,040,517	26	806.1	1.97	61.81
2-Jan-00	9-Jan-00	17,329,512	104	2941.4	6.02	169.74
10-Jan-00	16-Jan-00	17,234,569	54	1544.8	3.15	89.63
17-Jan-00	23-Jan-00	16,555,014	306	8533.5	18.47	515.47
24-Jan-00	30-Jan-00	17,657,018	106	3039.7	5.98	172.15
31-Jan-00	6-Feb-00	17,683,818	42	1238.1	2.37	70.01
7-Feb-00	13-Feb-00	17,704,714	70	1894.2	3.96	106.99
14-Feb-00	20-Feb-00	16,737,624	13	323.4	0.78	19.32
21-Feb-00	27-Feb-00	11,892,635	12	378.1	0.99	31.79
28-Feb-00	5-Mar-00	8,060,616	5	271.0	0.66	33.62
6-Mar-00	12-Mar-00	9,475,595	12	285.2	1.31	30.10
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	0	0.0	0.00	0.00
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	0	0.0	0.00	0.00
29-May-00	4-Jun-00	17,257,509	0	0.0	0.00	0.00
5-Jun-00	11-Jun-00	16,408,296	8	341.3	0.49	20.80
12-Jun-00	18-Jun-00	17,622,722	0	0.0	0.00	0.00
19-Jun-00	25-Jun-00	17,453,970	0	0.0	0.00	0.00
26-Jun-00	2-Jul-00	17,659,970	0	0.0	0.00	0.00
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	0	0.0	0.00	0.00
17-Jul-00	23-Jul-00	16,536,163	0	0.0	0.00	0.00
24-Jul-00	2-Aug-00	24,898,843	0	0.0	0.00	0.00
3-Aug-00	13-Aug-00	27,339,851	0	0.0	0.00	0.00
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	0	0.0	0.00	0.00
28-Aug-00	3-Sep-00	16,640,754	0	0.0	0.00	0.00
4-Sep-00	10-Sep-00	16,820,636	0	0.0	0.00	0.00
		Totals:	1,024	30773.5		

Table H2-16. Estimates of the weekly numbers and biomass purple sea urchin *Strongylocentrotus purpuratus* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6 m^3$)	Impingement Rate ($g/10^6 m^3$)
6-Sep-99	12-Sep-99	13,796,838	46	410.5	3.36	29.75
13-Sep-99	19-Sep-99	16,810,758	19	160.9	1.15	9.57
20-Sep-99	26-Sep-99	17,134,181	14	88.9	0.81	5.19
27-Sep-99	3-Oct-99	16,915,689	15	40.2	0.88	2.38
4-Oct-99	10-Oct-99	17,417,176	28	69.7	1.58	4.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	34	73.2	1.98	4.32
25-Oct-99	31-Oct-99	16,962,928	40	204.4	2.38	12.05
1-Nov-99	7-Nov-99	17,119,645	20	8.2	1.20	0.48
8-Nov-99	14-Nov-99	16,601,805	13	22.3	0.80	1.35
15-Nov-99	20-Nov-99	11,184,467	33	86.5	2.97	7.73
21-Nov-99	27-Nov-99	12,877,899	39	157.1	3.01	12.20
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	37	164.9	3.39	15.29
26-Dec-99	1-Jan-00	13,040,517	0	0.0	0.00	0.00
2-Jan-00	9-Jan-00	17,329,512	16	24.9	0.93	1.43
10-Jan-00	16-Jan-00	17,234,569	14	48.8	0.79	2.83
17-Jan-00	23-Jan-00	16,555,014	14	61.2	0.82	3.69
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	35	213.1	1.98	12.05
7-Feb-00	13-Feb-00	17,704,714	28	126.8	1.58	7.16
14-Feb-00	20-Feb-00	16,737,624	13	59.5	0.78	3.55
21-Feb-00	27-Feb-00	11,892,635	29	192.9	2.46	16.22
28-Feb-00	5-Mar-00	8,060,616	26	336.1	3.28	41.69
6-Mar-00	12-Mar-00	9,475,595	12	11.2	1.31	1.18
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	13	208.4	1.31	20.33
25-Mar-00	2-Apr-00	16,024,015	19	76.3	1.18	4.76
3-Apr-00	9-Apr-00	13,993,977	0	0.0	0.00	0.00
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	14	47.4	2.78	9.53
24-Apr-00	30-Apr-00	4,145,001	9	143.1	2.14	34.53
1-May-00	7-May-00	9,774,471	0	0.0	0.00	0.00
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	17	136.0	1.64	13.37
22-May-00	28-May-00	16,869,355	33	268.0	1.96	15.89
29-May-00	4-Jun-00	17,257,509	0	0.0	0.00	0.00
5-Jun-00	11-Jun-00	16,408,296	73	551.1	4.43	33.58
12-Jun-00	18-Jun-00	17,622,722	0	0.0	0.00	0.00
19-Jun-00	25-Jun-00	17,453,970	7	3.3	0.38	0.19
26-Jun-00	2-Jul-00	17,659,970	88	1329.7	4.96	75.30
3-Jul-00	9-Jul-00	13,755,343	54	854.5	3.90	62.12
10-Jul-00	16-Jul-00	16,861,860	60	795.6	3.56	47.18
17-Jul-00	23-Jul-00	16,536,163	19	141.0	1.13	8.53
24-Jul-00	2-Aug-00	24,898,843	39	8.7	1.55	0.35
3-Aug-00	13-Aug-00	27,339,851	131	231.7	4.77	8.47
14-Aug-00	20-Aug-00	17,389,693	29	7.9	1.65	0.45
21-Aug-00	27-Aug-00	17,477,023	64	30.1	3.65	1.72
28-Aug-00	3-Sep-00	16,640,754	33	135.9	1.97	8.17
4-Sep-00	10-Sep-00	16,820,636	45	50.8	2.68	3.02
		Totals:	1,269	7580.6		

Table H2-17. Estimates of the weekly numbers and biomass spotted bay shrimp *Crangon nigromaculata* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	0	0.0	0.00	0.00
13-Sep-99	19-Sep-99	16,810,758	0	0.0	0.00	0.00
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	0	0.0	0.00	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	0	0.0	0.00	0.00
25-Oct-99	31-Oct-99	16,962,928	0	0.0	0.00	0.00
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	0	0.0	0.00	0.00
15-Nov-99	20-Nov-99	11,184,467	0	0.0	0.00	0.00
21-Nov-99	27-Nov-99	12,877,899	0	0.0	0.00	0.00
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	0	0.0	0.00	0.00
13-Dec-99	18-Dec-99	11,732,285	18	21.5	1.53	1.84
19-Dec-99	25-Dec-99	10,784,727	16	31.4	1.45	2.91
26-Dec-99	1-Jan-00	13,040,517	19	35.4	1.48	2.71
2-Jan-00	9-Jan-00	17,329,512	16	46.5	0.93	2.68
10-Jan-00	16-Jan-00	17,234,569	41	84.8	2.36	4.92
17-Jan-00	23-Jan-00	16,555,014	0	0.0	0.00	0.00
24-Jan-00	30-Jan-00	17,657,018	35	76.0	1.99	4.30
31-Jan-00	6-Feb-00	17,683,818	21	18.2	1.19	1.03
7-Feb-00	13-Feb-00	17,704,714	21	23.8	1.19	1.35
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	346	1017.7	29.08	85.57
28-Feb-00	5-Mar-00	8,060,616	21	22.8	2.63	2.82
6-Mar-00	12-Mar-00	9,475,595	99	91.8	10.47	9.68
13-Mar-00	17-Mar-00	3,815,676	0	0.0	0.00	0.00
18-Mar-00	24-Mar-00	10,254,629	7	10.8	0.66	1.05
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	18	25.1	1.28	1.79
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	0	0.0	0.00	0.00
24-Apr-00	30-Apr-00	4,145,001	0	0.0	0.00	0.00
1-May-00	7-May-00	9,774,471	5	4.8	0.55	0.50
8-May-00	14-May-00	5,421,440	0	0.0	0.00	0.00
15-May-00	21-May-00	10,171,036	0	0.0	0.00	0.00
22-May-00	28-May-00	16,869,355	20	31.0	1.17	1.84
29-May-00	4-Jun-00	17,257,509	61	95.3	3.55	5.52
5-Jun-00	11-Jun-00	16,408,296	32	58.1	1.97	3.54
12-Jun-00	18-Jun-00	17,622,722	135	287.8	7.65	16.33
19-Jun-00	25-Jun-00	17,453,970	13	36.8	0.75	2.11
26-Jun-00	2-Jul-00	17,659,970	0	0.0	0.00	0.00
3-Jul-00	9-Jul-00	13,755,343	0	0.0	0.00	0.00
10-Jul-00	16-Jul-00	16,861,860	33	125.4	1.98	7.44
17-Jul-00	23-Jul-00	16,536,163	19	43.5	1.13	2.63
24-Jul-00	2-Aug-00	24,898,843	58	149.0	2.33	5.98
3-Aug-00	13-Aug-00	27,339,851	11	35.9	0.40	1.31
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	0	0.0	0.00	0.00
28-Aug-00	3-Sep-00	16,640,754	0	0.0	0.00	0.00
4-Sep-00	10-Sep-00	16,820,636	6	29.0	0.38	1.72
		Totals:	1,072	2402.1		

Table H2-18. Estimates of the weekly numbers and biomass sheep crab *Loxorhyncus crispatus* impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	7	463.4	0.48	33.59
13-Sep-99	19-Sep-99	16,810,758	13	220.2	0.77	13.10
20-Sep-99	26-Sep-99	17,134,181	0	0.0	0.00	0.00
27-Sep-99	3-Oct-99	16,915,689	0	0.0	0.00	0.00
4-Oct-99	10-Oct-99	17,417,176	7	3.4	0.40	0.20
11-Oct-99	17-Oct-99	14,921,089	6	13.7	0.42	0.92
18-Oct-99	24-Oct-99	16,926,137	7	3.4	0.40	0.20
25-Oct-99	31-Oct-99	16,962,928	13	5.4	0.79	0.32
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	20	26.0	1.20	1.57
15-Nov-99	20-Nov-99	11,184,467	22	61.5	1.98	5.50
21-Nov-99	27-Nov-99	12,877,899	13	22.0	1.00	1.71
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	7	14.6	0.52	1.03
13-Dec-99	18-Dec-99	11,732,285	12	364.5	1.02	31.07
19-Dec-99	25-Dec-99	10,784,727	31	132.2	2.91	12.26
26-Dec-99	1-Jan-00	13,040,517	13	13.5	0.99	1.04
2-Jan-00	9-Jan-00	17,329,512	8	7.2	0.46	0.42
10-Jan-00	16-Jan-00	17,234,569	20	97.7	1.18	5.67
17-Jan-00	23-Jan-00	16,555,014	7	5.4	0.41	0.33
24-Jan-00	30-Jan-00	17,657,018	0	0.0	0.00	0.00
31-Jan-00	6-Feb-00	17,683,818	7	2.1	0.40	0.12
7-Feb-00	13-Feb-00	17,704,714	0	0.0	0.00	0.00
14-Feb-00	20-Feb-00	16,737,624	0	0.0	0.00	0.00
21-Feb-00	27-Feb-00	11,892,635	94	274.6	7.89	23.09
28-Feb-00	5-Mar-00	8,060,616	0	0.0	0.00	0.00
6-Mar-00	12-Mar-00	9,475,595	6	3.1	0.65	0.33
13-Mar-00	17-Mar-00	3,815,676	5	11.5	1.31	3.02
18-Mar-00	24-Mar-00	10,254,629	7	8.7	0.66	0.85
25-Mar-00	2-Apr-00	16,024,015	0	0.0	0.00	0.00
3-Apr-00	9-Apr-00	13,993,977	42	31.9	2.99	2.28
10-Apr-00	16-Apr-00	8,110,119	0	0.0	0.00	0.00
17-Apr-00	23-Apr-00	4,969,914	5	1.8	0.93	0.37
24-Apr-00	30-Apr-00	4,145,001	4	9.3	1.07	2.25
1-May-00	7-May-00	9,774,471	32	101.0	3.31	10.33
8-May-00	14-May-00	5,421,440	7	5.7	1.31	1.05
15-May-00	21-May-00	10,171,036	6	24.4	0.55	2.40
22-May-00	28-May-00	16,869,355	7	4.0	0.39	0.23
29-May-00	4-Jun-00	17,257,509	14	51.1	0.79	2.96
5-Jun-00	11-Jun-00	16,408,296	48	59.7	2.95	3.64
12-Jun-00	18-Jun-00	17,622,722	10	20.2	0.55	1.15
19-Jun-00	25-Jun-00	17,453,970	13	26.3	0.75	1.51
26-Jun-00	2-Jul-00	17,659,970	38	154.0	2.13	8.72
3-Jul-00	9-Jul-00	13,755,343	31	75.0	2.23	5.46
10-Jul-00	16-Jul-00	16,861,860	47	84.7	2.77	5.02
17-Jul-00	23-Jul-00	16,536,163	19	23.0	1.13	1.39
24-Jul-00	2-Aug-00	24,898,843	10	72.5	0.39	2.91
3-Aug-00	13-Aug-00	27,339,851	44	140.3	1.59	5.13
14-Aug-00	20-Aug-00	17,389,693	0	0.0	0.00	0.00
21-Aug-00	27-Aug-00	17,477,023	18	28.2	1.04	1.62
28-Aug-00	3-Sep-00	16,640,754	20	63.0	1.18	3.79
4-Sep-00	10-Sep-00	16,820,636	26	709.2	1.53	42.16
		Totals:	763	3439.6		

Table H2-19. Estimates of the weekly numbers and biomass Family Cancridae impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate (#/10^6 m^3)	Impingement Rate (g/10^6 m^3)
6-Sep-99	12-Sep-99	13,796,838	172	5349.8	12.48	387.76
13-Sep-99	19-Sep-99	16,810,758	174	1171.6	10.34	69.69
20-Sep-99	26-Sep-99	17,134,181	188	3376.1	10.95	197.04
27-Sep-99	3-Oct-99	16,915,689	156	3007.6	9.24	177.80
4-Oct-99	10-Oct-99	17,417,176	55	1759.9	3.17	101.04
11-Oct-99	17-Oct-99	14,921,089	56	4012.8	3.76	268.94
18-Oct-99	24-Oct-99	16,926,137	168	961.0	9.92	56.77
25-Oct-99	31-Oct-99	16,962,928	81	306.7	4.76	18.08
1-Nov-99	7-Nov-99	17,119,645	89	520.8	5.18	30.42
8-Nov-99	14-Nov-99	16,601,805	133	4318.8	8.03	260.14
15-Nov-99	20-Nov-99	11,184,467	72	214.6	6.44	19.18
21-Nov-99	27-Nov-99	12,877,899	252	1826.4	19.58	141.82
28-Nov-99	5-Dec-99	12,162,467	80	141.9	6.56	11.67
6-Dec-99	12-Dec-99	14,173,408	212	1013.4	14.98	71.50
13-Dec-99	18-Dec-99	11,732,285	132	671.0	11.22	57.19
19-Dec-99	25-Dec-99	10,784,727	167	1088.2	15.51	100.90
26-Dec-99	1-Jan-00	13,040,517	187	782.6	14.31	60.01
2-Jan-00	9-Jan-00	17,329,512	209	4244.1	12.03	244.91
10-Jan-00	16-Jan-00	17,234,569	176	1626.2	10.23	94.36
17-Jan-00	23-Jan-00	16,555,014	163	3729.6	9.85	225.29
24-Jan-00	30-Jan-00	17,657,018	169	912.4	9.56	51.67
31-Jan-00	6-Feb-00	17,683,818	238	742.0	13.43	41.96
7-Feb-00	13-Feb-00	17,704,714	210	914.2	11.87	51.63
14-Feb-00	20-Feb-00	16,737,624	301	1834.1	17.96	109.58
21-Feb-00	27-Feb-00	11,892,635	193	1200.2	16.27	100.92
28-Feb-00	5-Mar-00	8,060,616	101	197.9	12.47	24.56
6-Mar-00	12-Mar-00	9,475,595	87	624.3	9.16	65.89
13-Mar-00	17-Mar-00	3,815,676	30	150.1	7.87	39.34
18-Mar-00	24-Mar-00	10,254,629	182	1171.2	17.70	114.21
25-Mar-00	2-Apr-00	16,024,015	198	843.6	12.34	52.65
3-Apr-00	9-Apr-00	13,993,977	334	921.6	23.89	65.86
10-Apr-00	16-Apr-00	8,110,119	89	213.8	10.94	26.36
17-Apr-00	23-Apr-00	4,969,914	41	228.2	8.33	45.91
24-Apr-00	30-Apr-00	4,145,001	71	223.3	17.11	53.88
1-May-00	7-May-00	9,774,471	129	500.5	13.23	51.20
8-May-00	14-May-00	5,421,440	71	249.4	13.10	45.99
15-May-00	21-May-00	10,171,036	277	1742.4	27.28	171.31
22-May-00	28-May-00	16,869,355	119	209.2	7.04	12.40
29-May-00	4-Jun-00	17,257,509	422	2837.4	24.46	164.42
5-Jun-00	11-Jun-00	16,408,296	250	1535.4	15.24	93.58
12-Jun-00	18-Jun-00	17,622,722	173	375.0	9.83	21.28
19-Jun-00	25-Jun-00	17,453,970	164	938.9	9.41	53.80
26-Jun-00	2-Jul-00	17,659,970	713	8758.1	40.40	495.93
3-Jul-00	9-Jul-00	13,755,343	429	3908.3	31.17	284.13
10-Jul-00	16-Jul-00	16,861,860	720	5347.7	42.71	317.15
17-Jul-00	23-Jul-00	16,536,163	441	3683.1	26.67	222.73
24-Jul-00	2-Aug-00	24,898,843	1,325	7639.3	53.22	306.81
3-Aug-00	13-Aug-00	27,339,851	1,022	8707.1	37.40	318.48
14-Aug-00	20-Aug-00	17,389,693	387	8806.5	22.25	506.42
21-Aug-00	27-Aug-00	17,477,023	619	6462.6	35.43	369.78
28-Aug-00	3-Sep-00	16,640,754	276	2776.7	16.57	166.86
4-Sep-00	10-Sep-00	16,820,636	257	7443.0	15.30	442.49
		Totals:	12,961	122220.5		

Table H2-20. Estimates of the weekly numbers and biomass unidentified cancer crabs *Cancer* spp. impinged at the MBPP September 6, 1999 through September 10, 2000.

Survey Start	End	Total Flow (m^3)	Estimate of Total (#)	Estimate of Total (g)	Impingement Rate ($\#/10^6\ m^3$)	Impingement Rate ($g/10^6\ m^3$)
6-Sep-99	12-Sep-99	13,796,838	46	76.1	3.36	5.52
13-Sep-99	19-Sep-99	16,810,758	19	43.1	1.15	2.57
20-Sep-99	26-Sep-99	17,134,181	14	22.2	0.81	1.30
27-Sep-99	3-Oct-99	16,915,689	7	3.7	0.44	0.22
4-Oct-99	10-Oct-99	17,417,176	7	*	0.40	0.00
11-Oct-99	17-Oct-99	14,921,089	0	0.0	0.00	0.00
18-Oct-99	24-Oct-99	16,926,137	54	118.9	3.17	7.02
25-Oct-99	31-Oct-99	16,962,928	40	16.1	2.38	0.95
1-Nov-99	7-Nov-99	17,119,645	0	0.0	0.00	0.00
8-Nov-99	14-Nov-99	16,601,805	33	30.0	2.01	1.81
15-Nov-99	20-Nov-99	11,184,467	50	47.1	4.46	4.21
21-Nov-99	27-Nov-99	12,877,899	78	77.6	6.02	6.03
28-Nov-99	5-Dec-99	12,162,467	0	0.0	0.00	0.00
6-Dec-99	12-Dec-99	14,173,408	37	33.7	2.58	2.38
13-Dec-99	18-Dec-99	11,732,285	0	0.0	0.00	0.00
19-Dec-99	25-Dec-99	10,784,727	5	0.5	0.48	0.05
26-Dec-99	1-Jan-00	13,040,517	64	45.0	4.93	3.45
2-Jan-00	9-Jan-00	17,329,512	16	14.4	0.93	0.83
10-Jan-00	16-Jan-00	17,234,569	34	10.2	1.97	0.59
17-Jan-00	23-Jan-00	16,555,014	68	62.2	4.10	3.76
24-Jan-00	30-Jan-00	17,657,018	35	17.6	1.99	1.00
31-Jan-00	6-Feb-00	17,683,818	77	27.9	4.35	1.58
7-Feb-00	13-Feb-00	17,704,714	119	101.6	6.73	5.74
14-Feb-00	20-Feb-00	16,737,624	118	76.4	7.03	4.57
21-Feb-00	27-Feb-00	11,892,635	29	92.6	2.46	7.79
28-Feb-00	5-Mar-00	8,060,616	32	18.5	3.94	2.30
6-Mar-00	12-Mar-00	9,475,595	19	18.6	1.96	1.96
13-Mar-00	17-Mar-00	3,815,676	20	34.5	5.25	9.05
18-Mar-00	24-Mar-00	10,254,629	61	87.4	5.90	8.52
25-Mar-00	2-Apr-00	16,024,015	66	56.5	4.11	3.53
3-Apr-00	9-Apr-00	13,993,977	48	76.8	3.41	5.49
10-Apr-00	16-Apr-00	8,110,119	53	47.9	6.56	5.91
17-Apr-00	23-Apr-00	4,969,914	9	2.8	1.85	0.56
24-Apr-00	30-Apr-00	4,145,001	9	6.6	2.14	1.60
1-May-00	7-May-00	9,774,471	11	17.8	1.10	1.82
8-May-00	14-May-00	5,421,440	50	46.9	9.17	8.65
15-May-00	21-May-00	10,171,036	67	84.4	6.55	8.29
22-May-00	28-May-00	16,869,355	13	5.9	0.78	0.35
29-May-00	4-Jun-00	17,257,509	109	108.2	6.31	6.27
5-Jun-00	11-Jun-00	16,408,296	65	56.5	3.93	3.44
12-Jun-00	18-Jun-00	17,622,722	0	0.0	0.00	0.00
19-Jun-00	25-Jun-00	17,453,970	26	41.4	1.51	2.37
26-Jun-00	2-Jul-00	17,659,970	50	115.2	2.84	6.52
3-Jul-00	9-Jul-00	13,755,343	153	166.9	11.13	12.13
10-Jul-00	16-Jul-00	16,861,860	287	337.3	17.01	20.00
17-Jul-00	23-Jul-00	16,536,163	130	212.4	7.89	12.85
24-Jul-00	2-Aug-00	24,898,843	571	684.8	22.92	27.50
3-Aug-00	13-Aug-00	27,339,851	283	485.1	10.34	17.74
14-Aug-00	20-Aug-00	17,389,693	43	27.9	2.47	1.61
21-Aug-00	27-Aug-00	17,477,023	18	7.9	1.04	0.45
28-Aug-00	3-Sep-00	16,640,754	0	0.0	0.00	0.00
4-Sep-00	10-Sep-00	16,820,636	0	0.0	0.00	0.00
		Totals:	3,142	3665.6		

* Weight unobtainable.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix I

CDFG Morro Bay Otter Trawl Data, Pacific States Marine Fisheries Commission (PSMFC) PacFin Data, and California Department of Fish and Game (CDFG) Commercial Landings

APPENDIX I

This appendix contains three set of data: (1) CDFG Morro Bay otter trawl survey results from the years 1992 through 1999 (source: CDFG unpublished data), (2) Pacific States Marine Fisheries Commission (PSMFC) PacFin Data commercial landings data, both by dollar value and by weight (data from PacFin website, query dated May 4, 2001), and (3) CDFG poundage and value of landings of commercial fish into California by area for the year 1999 (source: California Department of Fish and Game, 2000, Final California Commercial Landings for 1999).

Morro Bay Power Plant Modernization Project
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Appendix I

Part 1

CDFG Morro Bay Otter Trawl Survey Results, 1992 through 1999

APPENDIX I PART 1
CDFG MORRO BAY OTTER TRAWL SURVEY RESULTS
1992 THROUGH 1999

The California Department of Fish and Game (CDFG) otter trawl survey of the Morro Bay estuary was conducted on a monthly basis from March 1992 through March 1995 (except May 1993) and on a semi-monthly basis between March 1995 and July 1999. A total of two sampling efforts was made between November 1995 and January1998 (April 1996 and October 1997) because no vessel was available to conduct the surveys. Five tow locations were chosen within the bay; one in the outer harbor, two in the mid-harbor area and two in the back-bay. The outer harbor station, located between the west and south breakwaters, was abandoned after November 1993 because sedimentation near the harbor mouth created unsafe conditions for the survey.

Table I-1a. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 1 during 1992.

Common Name	1992 Total	1992 Range	Station 1: 1992																	
			April		May		June		July		August		September		October		November		December	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	517	15-142	14	45-112	70	27-117	77	38-118	50	15-142	87	31-115	61	42-132	86	43-111	56	40-129	16	42-127
bay pipefish	159	78-288	4	109-218	28	100-220	49	131-288	21	78-255	27	129-249	9	153-233	14	122-220	6	131-230	1	140
staghorn sculpin	43	84-147			12	86-109	11	84-112	8	95-130	5	105-145	3	110-147	2	118-120	2	104-105		
cabezon	41	47-114			6	47-53	9	48-75	4	66-86	17	62-114	5	50-95						
round stingray	23	320-456															5	327-456	18	320-426
California halibut	9	188-702	1	672					1	380			4	188-702	1	385	1	663	1	263
English sole	7	32-82			2	32-82	1	48	3	47-63	1	37								
striped kelpfish	7	60-113					1	74			2		4	60-113						
pricklebreast poacher	5	48-104							4	48-63					1	104				
poacher, unidentified	4	44-46					4	44-46												
tubesnout	3	89-127	2	89-101					1	127										
sand sole	3	304-318													1	311	2	304-318		
spotfin surfperch	2	53-56			1	56			1	53										
bay goby	2	25							2	25										
big skate	1	331	1	331																
bocaccio	1	98											1	98						
plainfin midshipman	1	38									1	38								
shiner surfperch	1	57							1	57										
Total	829		22		119		152		96		140		87		105		72		36	

Table I-1b. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 1 during 1993.

Common Name	1993 Total	1993 Range	Station 1: 1993															
			Mar		Apr		Jun		Jul		Aug		Sep		Oct		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	127	27-116	1	49	1	66	1	90	6	54-102	11	55-99	19	44-105	38	56-116	50	27-115
bay pipefish	41	86-230									22	129-230	8	86-208	4	100-188	7	102-190
English sole	16	50-92					1	60	7	50-58	7	56-92					1	50
spotfin surfperch	11	52-59									11	52-59						
tubesnout	3	122-126									3	122-126						
diamond turbot	3	212-244	1	244					1	239			1	212				
staghorn sculpin	2	105-131							1	105	1	131						
sand sole	2	54-75							1	54	1	75						
California halibut	1	149													1	149		
pricklebreast poacher	1	22									1	22						
walleye surfperch	1	93									1	93						
white surfperch	1	73									1	73						
Total	209		2		1		2		16		59		28		43		58	

Table I-2a. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1992.

Common Name	1992 Totals	1992 Range	Station 2: 1992																			
			Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	1,059	30-118	16	30-60	27	31-55	50	31-87	96	35-95	64	32-90	165	31-99	336	30-115	184	36-118	97	38-115	24	34-69
bay pipefish	131	102-241	3	116-135	14	109-222	18	102-218	21	140-226	7	171-225	13	102-224	7	133-230	38	129-241	6	148-191	4	104-168
northern anchovy	91				91																	
staghorn sculpin	32	77-136					8	77-115	8	91-110	3	98-113	6	100-125	7	105-136						
spotfin surfperch	16	50-65					2		14	50-65												
English sole	15	37-99					8	57-80	1	82	1	67	3	37-99	2	59-79						
shiner surfperch	12	53-65							12	53-65												
tubesnout	9	120-140											3	127-140	5	120-137	1	133				
cabezon	3	70-95			1	70	1	74							1	95						
California halibut	3	210-305											1	215	1	305	1	210				
sand sole	3	199-305					1	199			2	290-305										
sarcastic fringehead	3	53-149	1	53					1	83			1	149								
round stingray	2	365-394																	1	365	1	394
bonyhead sculpin	1	47													1	47						
kelp clingfish	1				1																	
lingcod	1	86	1	86																		
California lizardfish	1	108					1	108														
plainfin midshipman	1	35													1	35						
rubberlip surfperch	1	98									1	98										
starry flounder	1	299																	1	299		
striped kelpfish	1						1															
Total	1,387		21		134		90		153		78		192		361		224		105		29	

Table I-2b. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1993.

Common Name	1993 Total	1993 Range	Station 2: 1993																					
			Jan		Feb		Mar		Apr		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	505	28-119	32	34-60	5	44-65	13	38-74	5	46-75	23	40-102	5	45-100	43	46-112	55	32-98	196	29-119	40	28-89	88	30-82
English sole	185	30-115							2	50-51	93	30-99	22	51-80	60	48-87	5	68-99	2	115			1	53
bay pipefish	38	113-256	1	186	2	117-139	3	150-256			1	200	3	113-208	8	120-211	11	125-214	2	180-203	2	147-187	5	125-197
plainfin midshipman	7	40-52																	4	40-52			3	42-48
tubesnout	3	95-152	2	95-108																			1	152
giant kelpfish	2	125-126					2	125-126																
seniorita	2	71-74					2	71-74																
cabezon	1	58							1	58														
California halibut	1	179																	1	179				
diamond turbot	1	205																	1	205				
lingcod	1	122															1	122						
round stingray	1	358																	1	358				
sarcastic fringehead	1	138			1	138																		
California tonguefish	1	101																	1	101				
Total	749		35		8		20		8		117		30		111		72		208		42		98	

Table I-2c. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1994.

Common Name	1994 Total	1994 Range	Station 2: 1994																							
			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	4,101	29-122	318	32-89	154	30-97	152	29-73	386	31-89	736	31-110	514	35-118	639	40-111	368	41-122	390	35-116	72	38-113	322	29-121	50	30-85
English sole	235	19-128			1	19					68	22-70	32	33-85	28	39-105	81	66-111	22	76-114	3	106-128				
lingcod	101	81-243	1	243			1	81					42	107-146	28	109-168	15	132-190	12	147-203	2	195-231				
staghorn sculpin	70	84-131									8	95-122	17	90-118	32	84-131	6	104-123	7	109-125						
bay pipefish	35	98-219	3	155-202	4	108-179			4	147-211			2	196-219	2	200-208			5	166-178	7	98-216	5	98-194	3	109-146
tubesnout	32	98-159							3	98-106															29	100-159
cabezon	24	41-221	1	46	2	41-57			2	42-45	1	62	6	54-81	6	54-100	3	67-105	1	123	1	221			1	194
Syngnathus exilis	23	146-261															5	190-245	13	196-253	3	234-261			2	146-175
shiner surfperch	21	96-134											18	96-134	1	113	2	119-121								
plainfin midshipman	6	32-174											4	161-174											2	32-42
vermilion rockfish	3	34-94	1	34									2	71-94												
curlfin turbot	2	73-98															2	73-98								
sarcastic fringehead	2	84-87															2	84-87								
white surfperch	2	89-91											2	89-91												
bonyhead sculpin	1	92																	1	92						
giant kelpfish	1	130																							1	130
jack mackerel	1	169											1	169												
night smelt	1	78			1	78																				
penpoint gunnel	1	134																							1	134
rockweed gunnel	1	90																					1	90		
round stingray	1	355									1	355														
sand sole	1	284																					1	284		
spotted turbot	1	142																	1	142						
striped kelpfish	1	76																					1	76		
Total	4,667		324		162		153		395		814		640		736		484		452		88		330		89	

Table I-2d. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1995.

Common Name	1995 Total	1995 Range	Station 2: 1995													
			Jan		Feb		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	773	31-114	115	35-108	67	39-101	318	31-114	96	40-103	28	37-88	114	43-96	35	32-95
English sole	136	25-110			1	60	4	40-50	9	25-88	100	51-91	21	67-110	1	109-110
staghorn sculpin	91	73-151					1	90	14	95-151	57	73-143	19	100-124		
shiner surfperch	9	84-127					8	84-127			1	120				
California tonguefish	6	49-52					6	49-52								
bay pipefish	5	115-196			4	115-190									1	196
bay goby	4	32-90					1	89			2	79-90			1	32
Syngnathus exilis	4	180-212							1	186					3	180-212
sand sole	3	126-265	1	126			1	176							1	265
tubesnout	3	112-134	3	112-134												
cabezon	2	58-61			1	58	1	61								
lingcod	2	320-424	1	424					1	320						
starry flounder	2	351-382							1	382			1	351		
barred sand bass	1	146	1	146												
gopher rockfish	1	56											1	56		
California lizardfish	1	89									1	89				
spotted cusk-eel	1	122					1	122								
Pacific tomcod	1	56									1	56				
white surfperch	1	190					1	190								
Total	1,046		121		73		342		122		190		156		42	

Table I-2d. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1996.

Common Name	Station 2: 1996	
	Apr	
	Count	Range
speckled sanddab	137	33-84
English sole	75	24-81
northern anchovy	41	45-60
staghorn sculpin	10	71-113
Pacific herring	7	56-64
cabezon	3	40-46
bay goby	2	75-82
white surfperch	2	76-192
shiner surfperch	1	92
swell shark	1	444
Total	279	

Table I-2e. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1998.

Common Name	1998 Total	1998 Range	Station 2: 1998											
			Jan		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	170	24-123	23	34-85	27	33-90	52	40-107	2	76-86	27	24-100	39	38-123
shiner surfperch	75	86-151			12	86-102	34	104-151	29	106-138				
English sole	47	31-90					31	31-67	13	46-76	3	71-90		
staghorn sculpin	12	69-127					3	79-90	6	69-101	1	127	2	99-103
California tonguefish	6	58-71			2	65-67	4	58-71						
white surfperch	4	168-182	1	168			1	180	2	182				
pile surfperch	3	164-229			1	164			2	222-229				
plainfin midshipman	3	39-158					1	158			1	39	1	47
sarcastic fringehead	2	115-139					2	115-139						
spotted scorpionfish	2	44			2	44								
spotted cusk-eel	2	131-167					2	131-167						
bat ray	1	850					1	850						
bay goby	1	37					1	37						
bay pipefish	1	145					1	145						
California halibut	1	175									1	175		
lingcod	1	438							1	438				
sand sole	1	322					1	322						
Total	332		24	34-168	44	33-164	134	31-850	55	46-438	33	24-175	42	38-123

Table I-2f. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 2 during 1999.

Common Name	1999 Total	1999 Range	Station 2: 1999							
			Jan		Mar		May		Jul	
			Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	393	39-115	7	40-57	22	39-73	230	41-94	134	50-115
English sole	160	46-115					121	46-100	39	73-115
lingcod	87	98-178					18	98-144	69	114-178
Pacific herring	39	68-72					39	68-72		
staghorn sculpin	23	80-132					1	80	22	87-132
kelp greenling	12	90-125							12	90-125
vermilion rockfish	8	38-55			7	38-51	1	55		
pile surfperch	7	103-219							7	103-219
cabezon	4	75-150							4	75-150
black surfperch	1	75							1	75
bocaccio	1	118							1	118
gunnel, unidentified.	1	65					1	65		
northern anchovy	1	74					1	74		
plainfin midshipman	1	148					1	148		
rainbow surfperch	1	65							1	65
shiner surfperch	1	106					1	106		
white surfperch	1	136							1	136
Total	741		7		29		414		291	

Table I-3a. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1992.

Common Name	1992 Total	1992 Range	Station 3: 1992																			
			Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	1,519	31-116	58	50-87	72	31-89	64	41-106	85	37-115	89	33-113	99	33-106	376	31-110	313	37-116	235	32-114	128	32-108
bay pipefish	116	101-270	10		22	106-160	3	150-218	3	153-220	3	114-160	15	101-251	26	135-230	10	158-270	12	165-266	12	115-201
staghorn sculpin	28	85-141			1	141	2	85-101	10	95-105	2	90-101	2	116-119	8	100-128	3	115-126				
cabezon	23	43-132			3	53-86	7	43-64	4	60-69	1	76	4	68-109	2	90-125	2	80-132				
sarcastic fringehead	20	60-140			9	60-80	3	69-105	6	72-140			1	116			1	103				
northern anchovy	5	36-41			5	36-41																
c-o turbot	3	288-293											2	288-293	1	290						
English sole	3	46-94													2	46-59			1	94		
bay goby	2	31-73											1	31	1	73						
plainfin midshipman	2	56-120							1	120							1	56				
spotted turbot	2	114-213					1	213									1	114				
bat ray	1	300									1	300										
diamond turbot	1	203																	1	203		
shiner surfperch	1	127							1	127												
white surfperch	1	174			1	174																
Total	1,727		68		113		80		110		96		124		416		331		249		140	

Table I-3b. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1993.

Common Name	1993 Total	Range	Station 3: 1993																							
			Jan		Feb		Mar		Apr		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	637	34-127	85	36-85	25	39-105	23	42-77	9	55-83	69	47-127	75	39-118	25	52-106	18	42-123	67	53-119	93	35-114	148	34-102
bay pipefish	78	75-242	5	113-162	1	165	4	108-155			1	242	4	143-210	10	129-214	8	120-214	20	96-216	10	138-225	15	75-210
English sole	63	41-113									31	52-82	25	41-94	3	64-79	2	80-94	2	110-113				
plainfin midshipman	10	45-62	1	59	1	62																	8	45-62
tubesnout	9	97-143	2	134-140	2	124-136	1	126	1	137									1	130	1	97	1	143
cabezon	8	45-112							3	45-75	1	62			3	82-110			1	112				
grass rockfish	8	43-52											2		6	43-52								
lingcod	8	113-164											1	113	4	130-145	3	136-164						
staghorn sculpin	5	54-147	1	147					1	54	1	116							2	72-146				
c-o turbot	3	96-291			1	291																	2	96-290
rubberlip surfperch	3	97-105													3	97-105								
sarcastic fringehead	3	95-124									3	95-124												
California tonguefish	2	35-38					2	35-38																
white surfperch	2	85-214	1	214											1	85								
brown rockfish	1	67																	1	67				
California halibut	1	274											1	274										
diamond turbot	1	226																			1	226		
sand sole	1	339			1	339																		
shiner surfperch	1	105																			1	105		
Total	844		95		31		30		14		106		108		55		31		94		106		174	

Table I-3c. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1994.

Common Name	1994 Total	1994 Range	Station 3: 1994																							
			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	2,228	30-140	427	34-140	221	32-104	88	32-73	173	30-99	272	37-125	240	38-126	220	38-106	178	44-109	72	36-100	50	47-106	254	30-109	33	36-82
bay pipefish	106	85-232	5	114-155	3	96-171	7	95-134	7	131-150	4	157-226	12	143-201	7	191-232	1	205	13	119-190	14	119-229	28	85-216	5	133-192
lingcod	49	98-245									5	114-135	19	101-141	12	98-134	7	125-144	4	147-189	1	167			1	245
cabezon	48	39-149	1	39							12	52-75	18	62-91	6	60-105	3	70-112	5	89-149	2	71-144	1	127		
staghorn sculpin	41	68-151			1	151					7	71-123	7	99-112	16	68-123	7	98-118	3	125-136						
Syngnathus exilis	21	185-247															13	205-247	7	193-240			1	185		
English sole	18	35-90					1	38	1	55	8	35-75	6	35-67			1	62	1	90						
vermilion rockfish	8	36-88					1	46	2	36-50			4	51-88	1	72										
plainfin midshipman	7	46-174	1	48							1	150	3	167-174			1	115					1	46		
sarcastic fringehead	5	110-178			1	110			1	144					3	110-178										
shiner surfperch	5	106-126											5	106-126												
California tonguefish	5	53-79			1	53					1	64	1	75	2	72-79										
grass rockfish	4	42-132											1	132			3	42-50								
snubnose pipefish	4	105-150															4	105-150								
bonyhead sculpin	3	81-105																	2	81-105			1	84		
black surfperch	2	75-75									1	75							1							
c-o turbot	2	226-244	1	244																	1	226				
tubesnout	2	143-145	1	143															1	145						
northern anchovy	1	135													1	135										
spearnose poacher	1	90											1	90												
stripetail rockfish	1	45											1	45												
Total	2,561	30-247	436	34-244	227	32-171	97	32-134	184	30-150	311	35-226	318	35-201	268	38-232	218	42-247	109	36-240	68	47-229	286	30-216	39	36-245

Table I-3d. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1995.

Common Name	1995 Total	1995 Range	Station 3: 1995													
			Jan		Feb		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	562	32-120	31	34-98	63	41-97	204	32-120	169	37-116	6	56-101	38	42-90	51	35-92
shiner surfperch	196	54-147	1	92	25	78-127	11	94-139			159	54-147				
staghorn sculpin	42	82-165			2	150-165			17	99-128	20	82-165	3	91-102		
English sole	28	25-80					3	35-59	4	25-52	21	60-80				
California tonguefish	16	46-88					9	46-52	2	57-65	4	58-88	1	68		
bay goby	9	48-90					9	48-90								
white surfperch	9	164-261	2	226-246	6	164-261	1	208								
pile surfperch	8	196-306			3	196-231					5	231-306				
cabezon	4	47-107					1	47			1	66	2	81-107		
California halibut	4	257-686					1	482	3	257-686						
Syngnathus exilis	4	178-210					1	178	1	210			1	178	1	183
black surfperch	3	65-250			1	250	1	182	1	65						
sarcastic fringehead	3	95-136					1	106	2	95-136						
spotted cusk-eel	3	105-210					3	105-210								
bay pipefish	2	127-201	2	127-201												
lingcod	2	185-249			1	249							1	185		
sand sole	2	146-168					2	146-168								
bonyhead sculpin	1	107			1	107										
c-o turbot	1	80							1	80						
diamond turbot	1	245					1	245								
plainfin midshipman	1	51											1	51		
spearnose poacher	1	93	1	93												
starry flounder	1	360									1	360				
walleye surfperch	1	210									1	210				
Total	904		37	34-246	102	41-261	248	32-482	200	25-686	218	54-360	47	42-185	52	35-183

Table I-3e. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1996.

Common Name	Station 3: 1996	
	Apr	
	Count	Range
northern anchovy	50	34-49
speckled sanddab	32	36-82
English sole	21	46-75
white surfperch	6	174-214
staghorn sculpin	4	68-103
shiner surfperch	3	122-154
bay pipefish	1	147
cabezon	1	91
Pacific herring	1	51
pile surfperch	1	223
Syngnathus exilis	1	151
Total	121	

Table I-3f. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1998.

Common Name	1998 Total	1998 Range	Station 3: 1998											
			Jan		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
shiner surfperch	359	42-157	4	83-97	102	70-142	215	90-157	38	42-145				
speckled sanddab	124	34-105	8	34-76	19	51-88	19	54-98	3	74-85	11	39-96	64	39-105
California tonguefish	11	39-79			7	39-63	3	53-78	1	79				
bay pipefish	9	113-215	1	204	1	155	3	113-125			1	183	3	142-215
English sole	8	47-117					3	47-65	3	55-64	1	99	1	117
black surfperch	6	157-190					6	157-190						
pile surfperch	6	198-350	4	198-350	1	248	1	257						
staghorn sculpin	3	80-97					1	84	2	80-97				
California halibut	2	290-299					1	290	1	299				
plainfin midshipman	2	149-158					1	149	1	158				
bat ray	1	1050					1	1050						
California lizardfish	1	141											1	141
rubberlip surfperch	1	259					1	259						
starry flounder	1	264			1	264								
thornback	1	318							1	318				
topsmelt	1	275							1	275				
white surfperch	1	197	1	197										
Total	537		18	34-350	131	39-264	255	47-1050	51	42-318	13	39-183	69	39-215

Table I-3g. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 3 during 1999.

Common Name	1999 Total	1999 Range	Station 3: 1999							
			Jan		Mar		May		Jul	
			Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	578	41-115	37	45-114	35	41-82	361	46-106	145	51-115
shiner surfperch	105	44-149					34	84-143	71	44-149
English sole	57	51-96					52	51-93	5	75-96
staghorn sculpin	31	67-130			2	67-92	4	71-122	25	85-130
vermilion rockfish	25	35-61			14	35-46	11	42-61		
California tonguefish	16	44-85					7	44-85	9	46-75
cabezon	13	57-90					13	57-90		
lingcod	11	102-140					4	102-115	7	118-140
pile surfperch	9	92-286							9	92-286
California halibut	6	123-369	4	123-137	1	303			1	369
Pacific herring	3	64-69					3	64-69		
thornback	3	462-558							3	462-558
white surfperch	3	235-288					1	267	2	235-288
diamond turbot	2	198-241	2	198-241						
sand sole	2	285-318	1	285	1	318				
black surfperch	1	74							1	74
bocaccio	1	112							1	112
grass rockfish	1	50					1	50		
northern anchovy	1	22			1	22				
plainfin midshipman	1	151					1	151		
rockpool blenny	1	80					1	80		
shovelnose guitarfish	1	1025					1	1025		
turbot, unidentified	1	68					1	68		
Total	872	22-1025	44	45-285	54	22-318	495	42-1025	279	44-558

Table I-4a. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1992.

Common Name	1992 Total	1992 Range	Station 4: 1992																	
			Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	373	31-145	13	44-90	29	52-112	24	63-106	34	31-110	24	37-122	31	47-113	83	39-145	75	52-109	60	50-105
staghorn sculpin	206	44-131	25	44-102	61	73-131	62	72-118	32	76-107	4	88-114	6	91-114	16	97-113				
shiner surfperch	76	43-136	24	99-128	2	108-121	34	43-136	16	51-120										
English sole	75	31-95	20	31-78	37	42-86	10	58-95							1	67	5	75-91	2	74-85
bay pipefish	21	105-203	1	128	1	192			1	200	4	105-140			2	155-179	7	127-203	5	116-202
California halibut	17	68-746	2	170-746			5	68-509	2	410-440	3	161-306			1	170	4	179-290		
northern anchovy	12	42-52	12	42-52																
California tonguefish	11	46-92			3	47-65	4	46-92	4	61-69										
bay goby	9	23-61	5	23-59	2	60-61					2	23-24								
white croaker	7	27-33	7	27-33																
black surfperch	4	92-107							4	92-107										
California lizardfish	4	88-135			2	88-109	2	120-135												
Pacific sardine	4	41-44	4	41-44																
plainfin midshipman	4	33-60													1	52	3	33-60		
bat ray	2	580-790	2	580-790																
horn shark	2	160-165															2	160-165		
cabezon	1	42			1	42														
c-o turbot	1	60			1	60														
diamond turbot	1	203															1	203		
gopher rockfish	1												1							
round stingray	1	358			1	358														
sarcastic fringehead	1	79																	1	79
shovelnose guitarfish	1	965					1	965												
thornback	1	648							1	648										
Total	835	23-965	115	23-790	140	42-358	142	43-965	94	31-648	37	23-306	38	47-114	104	39-179	97	33-290	68	50-202

Table I-4b. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1993.

Common Name	1993 Total	1993 Range	Station 4: 1993																					
			Jan		Feb		Mar		Apr		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	274	32-127	82	40-117	51	48-89	21	51-92	7	71-114	5	46-85	1	111	6	67-114	4	60-80	11	59-123	25	38-127	61	32-125
English sole	126	30-124	1	85					10	30-62	58	32-85	42	52-92	4	70-79	1	113	7	104-124	2	99-100	1	55
bay pipefish	46	80-223	5	119-165	8	105-185	4	100-163			1	185	2	122-223	4	145-220	1	214	6	147-215	12	101-222	3	80-160
staghorn sculpin	30	35-157	6	117-157	2	35-77	2	57-62			7	88-136	9	96-142	3	99-145			1	133				
California halibut	25	63-431			2	224-270	4	149-330	5	198-313	1	310	1	284	1	305	1	431	3	64-358	6	63-329	1	132
plainfin midshipman	22	31-66	10	31-50											1	32			2	38-46	9	42-66		
California tonguefish	22	34-82	5	41-57	8	35-52	3	34-47					4	60-82	2	60-81								
topsmelt	15	163-198	15	163-198																				
grass rockfish	6	43-60											3	43-45	3	54-60								
horn shark	4	695-760	4	695-760																				
shiner surfperch	4	46-94	1	84									3	46-94										
round stingray	3	347-390							1	390			1	347					1	368				
thornback	3	425-655									1	655			1	515	1	425						
brown rockfish	2	50-59											2	50-59										
diamond turbot	2	211-224					1	211	1	224														
tubesnout	2	125-127	1	125	1	127																		
arrow goby	1	40									1	40												
bat ray	1	630									1	630												
bay goby	1	72					1	72																
sarcastic fringehead	1	101	1	101																				
shovelnose guitarfish	1	1060	1	1060																				
spotted cusk-eel	1	78	1	78																				
Rockfish, unidentified	1	34									1	34												
Total	593	30-1060	133	31-1060	72	35-270	36	34-330	24	30-390	76	32-655	68	43-347	25	32-515	8	60-431	31	38-368	54	38-329	66	32-160

Table I-4c. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1994.

Common Name	1994 Total	1994 Range	Station 4: 1994																							
			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	797	26-157	215	30-157	170	31-104	51	54-129	19	65-96	17	53-115	12	66-113	62	26-134	26	45-108	10	38-122	16	45-121	102	32-120	97	36-101
staghorn sculpin	299	39-158			2	49-97	12	39-74	27	46-80	50	64-116	67	64-114	78	81-118	47	72-122	13	90-117					3	113-158
English sole	149	23-116	2	52-68			5	25-47	4	26-68	22	23-76	40	25-92	43	23-78	17	28-83	12	52-116	3	84-108	1	93		
California tonguefish	77	44-95	3	45-51			15	45-66	20	44-73	17	58-79	10	62-93	12	58-95										
California halibut	68	108-528					5	108-199	10	116-244	13	151-424	22	110-454	5	240-528	3	213-342	8	240-361	2	247-265				
bay pipefish	42	70-209	9	70-201	4	146-195			2	149-150	3	153-186	1	170	3	114-185	2	130-150	7	99-209			5	105-190	6	107-198
plainfin midshipman	11	30-168	8	30-64									1	168					1	40	1	33				
night smelt	6	77-106					6	77-106																		
diamond turbot	3	189-235					1	235					1	189									1	215		
round stingray	3	348-395							2	348-395			1	376												
cabezon	2	76-102									1	76	1	102												
c-o turbot	2	119-230			1	230			1	119																
horn shark	2	693-725	1	693	1	725																				
lingcod	2	114-122											1	114	1	122										
vermilion rockfish	2	36-63					2	36-63																		
barred sand bass	1	122					1	122																		
giant kelpfish	1	58													1	58										
northern anchovy	1	74											1	74												
rubberlip surfperch	1	98													1	98										
shiner surfperch	1	123											1	123												
shovelnose guitarfish	1	326	1	326																						
spotted turbot	1	222					1	222																		
starry flounder	1	249											1	249												
Syngnathus exilis	1	220																	1	220						
tubesnout	1	155																							1	155
Total	1475		239	30-693	178	31-725	99	25-235	85	26-395	123	23-424	160	25-454	206	23-528	95	28-342	52	38-361	22	33-265	109	32-215	107	36-198

Table I-4d. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1995.

Common Name	1995 Total	1995 Range	Station 4: 1995 Jan Count	Jan Range	Feb Count	Feb Range	Mar Count	Mar Range	May Count	May Range	Jul Count	Jul Range	Sep Count	Sep Range	Nov Count	Nov Range
staghorn sculpin	1,861	21-160	1	130	17	56-155	84	21-160	440	68-131	1084	67-134	235	81-120		
northern anchovy	848	41-114			48	70-114	5	52-56			143	41-80	652	62-76		
shiner surfperch	234	60-140	2	89-120	82	82-135	27	80-134	74	60-140	36	94-140	13	75-126		
English sole	131	19-115	1	19	3	42-51			6	28-35	109	30-86	11	80-115	1	83
arrow goby	127	35-55					127	35-55								
speckled sanddab	125	40-124	41	42-105	65	42-124	9	40-78	2	72-84			1	111	7	57-84
bay goby	82	34-106					81	34-106			1	89				
dwarf surfperch	32	81-140			28	108-140	3	81-127			1	140				
California tonguefish	14	40-94			1	52	10	40-63	1	74	2	74-94				
bay pipefish	13	83-225			2	155-225	11	83-171								
California halibut	13	151-683	1	326	1	257	2	151-307	1	452	4	378-683	1	351	3	280-326
plainfin midshipman	9	41-155									6	145-155	1	46	2	41-43
night smelt	7	62-71	1	63	1	71									5	62-71
bonyhead sculpin	4	78-116	1	78	3	103-116										
starry flounder	4	139-351					1	236			1	310	1	139	1	351
bat ray	3	485-890			1	485					2	815-890				
black surfperch	3	153-236	1	236	2	153-165										
horn shark	3	750-771	1	771	1	750					1	766				
round stingray	3	325-360									2	325-348			1	360
leopard shark	2	250-270							1	250	1	270				
pacific herring	2	49					2	49								
c-o turbot	1	68					1	68								
jacksmelt	1	262	1	262												
California killifish	1	59					1	59								
rubberlip surfperch	1	99									1	99				
sand sole	1	150	1	150												
sarcastic fringehead	1	85	1	85												
thornback	1	395									1	395				
tubesnout	1	130	1	130												
walleye surfperch	1	50							1	50						
white surfperch	1	81							1	81						
Total	3,530		54	19-771	255	42-750	364	21-307	527	28-452	1395	30-890	915	46-351	20	41-360

Table I-4e. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1996.

Common Name	Station 4: 1996	
	Apr	
	Total	Range
English sole	681	20-89
staghorn sculpin	198	56-128
California halibut	15	168-374
northern anchovy	13	33-40
shiner surfperch	11	110-152
speckled sanddab	2	57-60
white surfperch	2	40
diamond turbot	1	278
Pacific herring	1	59
white croaker	1	30
rockfish, unidentified		
Total	925	20-374

Table I-4f. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1997.

Common Name	Station 4: 1997	
	Oct	
	Total	Range
speckled sanddab	17	48-102
round stingray	4	337-384
bay pipefish	3	80-190
California halibut	2	95-134
staghorn sculpin	1	103
starry flounder	1	216
Syngnathus exilis	1	179
Total	29	48-384

Table I-4g. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1998.

Common Name	1998 Total	1998 Range	Station 4: 1998 Jan Count	Jan Range	Mar Count	Mar Range	May Count	May Range	Jul Count	Jul Range	Sep Count	Sep Range	Nov Count	Nov Range
staghorn sculpin	278	56-172			40	62-172	36	56-113	198	60-110	4	91-127		
shiner surfperch	221	45-152			196	52-152	20	114-133	3	45-118	2	108-118		
California halibut	78	89-797			58	89-244	8	148-249	5	255-318	5	141-797	2	215-355
English sole	46	27-114			1	108	15	27-50	27	31-79	1	67	2	99-114
speckled sanddab	35	36-109	5	57-85	19	50-109	2	63-98			2	58-68	7	36-94
California tonguefish	35	46-91	1	56	9	46-70	17	61-90	8	63-91				
round stingray	27	287-444			7	343-395			3	302-374			17	287-444
northern anchovy	16	42-60					16	42-60						
Pacific herring	15	20-35			15	20-35								
bat ray	8	490-1100					5	640-1050	3	490-1100				
kelp bass	8	36-89	8	36-89										
topsmelt	7	70-183			1	183	2	122-132	4	70-181				
bay pipefish	2	163-240	2	163-240										
leopard shark	2	242-1200					1	242	1	1200				
plainfin midshipman	2	129-180					2	129-180						
thornback	2	413-509							2	413-509				
white croaker	2	34-39					1	39	1	34				
grass rockfish	1	101							1	101				
shovelnose guitarfish	1	263									1	263		
snubnose pipefish	1	104	1	104										
starry flounder	1	275			1	275								
Total	788	20-1200	17	36-240	347	20-395	125	27-1050	256	31-1200	15	58-797	28	36-444

Table I-4h. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 4 during 1999.

Common Name	1999 Total	1999 Range	Station 4: 1999 Jan Count	Jan Range	Mar Count	Mar Range	May Count	May Range	Jul Count	Jul Range
Pacific herring	574	30-45			574	30-45				
northern anchovy	188	30-74	2	47-50	181	30-60	5	44-74		
staghorn sculpin	152	44-146	1	57	8	44-112	56	63-146	87	69-131
speckled sanddab	92	45-88			14	45-62	76	46-88	2	49-62
English sole	63	34-98			5	34-54	58	51-98		
shiner surfperch	21	46-146			2	144-146	6	121-145	13	46-128
California halibut	19	102-644	2	102-147	5	106-472	8	190-355	4	243-644
bay pipefish	6	91-222							6	91-222
starry flounder	5	251-512	1	423	2	251-280	1	303	1	512
bat ray	4	545-1023					2	545-1023	2	675-705
queenfish	3	81-95					3	81-95		
black rockfish	2	57-62							2	57-62
arrow goby	1	62					1	62		
diamond turbot	1	218	1	218						
grass rockfish	1	90					1	90		
horn shark	1	715	1	715						
leopard shark	1	264							1	264
night smelt	1	57							1	57
shovelnose guitarfish	1	885					1	885		
Syngnathus exilis	1	198							1	198
topsmelt	1	91					1	91		
Total	1138		8	47-715	791	30-472	219	44-1023	120	46-705

Table I-5a. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1992.

Common Name	1992 Total	1992 Range	Station 5: 1992																	
			Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
northern anchovy	348	35-75	3	35-38	345	50-75														
speckled sanddab	258	36-117	15	36-106	27	52-114	24	74-116	29	72-110	16	36-114	16	43-105	71	36-117	33	43-116	27	38-76
staghorn sculpin	166	20-134	32	40-128	44	20-110	46	86-129	32	80-115	9	83-134			3	94-130				
shiner surfperch	69	37-149	45	89-149	6	110-130	9	112-135	8	37-120	1	65								
bay pipefish	57	50-219			5	50-179	2	90-200	1	195	16	77-167	7	81-219	6	142-190	11	92-202	9	105-200
English sole	46	31-95	12	31-56	26	36-95	2	81-84							5	58-78	1	74		
California halibut	31	87-440			3	87-440	5	93-267	7	106-386	7	142-214	3	153-222	6	162-218				
California tonguefish	20	37-94	2	50	6	37-58	6	41-94	5	50-62	1	89								
bay goby	17	20-58	4	23-29	1	20	2	48-58	10	25										
plainfin midshipman	7	27-35							3	27-30			1	27					3	34-35
bat ray	2	470-614	1	614			1	470												
round stingray	2	275-390	1	390													1	275		
white croaker	2	26-27	2	26-27																
black surfperch	1	140									1	140								
diamond turbot	1	189													1	189				
horn shark	1	327			1	327														
California lizardfish	1	171							1	171										
rubberlip surfperch	1	99					1	99												
tubesnout	1	141													1	141				
white surfperch	1	65					1	65												
Total	1,032		117	23-614	464	20-440	99	41-470	96	25-386	51	36-214	27	27-222	93	36-218	46	43-275	39	34-200

Table I-5b. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1993.

Common Name	1993 Total	1993 Range	Station 5: 1993																					
			Jan		Feb		Mar		Apr		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	345	36-129	38	36-107	41	37-89	41	48-96	7	41-96	15	72-115	12	47-123	21	58-129	30	42-121	37	37-121	49	36-111	54	36-124
bay pipefish	105	62-248	24	70-189	6	89-228	7	109-145	2	113-120	1	85	2	106-125	9	78-191	5	85-174	6	80-154	40	62-248	3	193-205
English sole	55	15-107							4	15-47	23	36-80	21	54-87	1	70	2	92-104	4	103-107				
California halibut	48	17-614	1	143	4	204-266	13	118-275	1	256	1	614	3	290-367	2	284-348	8	31-192	8	85-251	4	17-90	3	52-81
plainfin midshipman	33	30-65	1	48											1	30	5	33-51	5	39-50	18	34-65	3	47-51
California tonguefish	32	33-90	3	46-50	6	33-46	17	37-59			1	59			2	65-90	3	70-80						
staghorn sculpin	22	32-150	8	104-124			5	32-96	1	105	4	78-150			2	121-124			1	107	1	128		
round stingray	9	331-409			2	372-409	1	395					3	340-399	2	331-370			1	360				
bay goby	5	25-87	2	80-87									1	39							2	25-52		
grass rockfish	4	36-63											1	36	3	56-63								
horn shark	3	168-747			1	747	1	168	1	740														
shovelnose guitarfish	3	257-892											1	892	1	879			1	257				
bat ray	2	775-803									1	775	1	803										
brown rockfish	2	45-60													2	45-60								
northern anchovy	2	48							2	48														
pile surfperch	2	266-302					2	266-302																
shiner surfperch	2	70-102							1	102			1	70										
starry flounder	2	118-321					1	321											1	118				
black surfperch	1	130	1	130																				
bonyhead sculpin	1	107																					1	107
c-o turbot	1	98																					1	98
diamond turbot	1	196															1	196						
kelp bass	1	30	1	30																				
spotted turbot	1	83																			1	83		
thornback	1	506									1	506												
tubesnout	1	153							1	153														
white surfperch	1	111	1	111																				
Total	685		80	30-189	60	33-747	88	32-395	20	15-740	47	36-775	46	36-892	46	30-879	54	31-196	64	37-360	115	17-248	65	36-205

Table I-5c. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1994.

Common Name	1994 Totals	1994 Range	Station 5: 1994																							
			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
speckled sanddab	707	33-139	167	34-128	55	37-136	92	33-104	42	35-115	35	44-122	26	66-125	54	36-132	48	44-124	19	66-139	20	44-128	79	42-115	70	35-119
English sole	240	22-111					21	30-48	8	52-67	51	22-75	70	23-89	51	23-89	36	28-94	2	64-85	1	111				
California tonguefish	144	25-94	3	47-69	2	55-65	58	35-78	33	45-76	24	55-83	16	58-94	3	73-86	4	58-85							1	25
staghorn sculpin	138	43-171	3	43-135			1	171	1	125	17	77-112	10	75-100	37	70-119	63	68-125	2	95-114					4	111-136
bay pipefish	72	63-244	5	81-200	3	106-166	1	162			4	131-201	1	185	21	63-235	1	94	1	135			27	70-195	8	66-244
California halibut	32	104-520					6	104-495	4	156-520	4	224-373	4	170-401	3	246-255	7	166-301	1	181	3	219-251				
plainfin midshipman	15	32-168	4	41-62							1	168							2	32-47			3	36-48	5	40-57
tubesnout	8	85-138																					1	85	7	105-138
shiner surfperch	7	42-118											2	110-111	3	42-109	2	60-118								
horn shark	6	180-825			2	700-750	1	180					1	233	2	724-825										
round stingray	4	307-420			1	420			1	307											2	370-395				
striped kelpfish	4	92-110													4	92-110										
bat ray	2	1080-1100					1	1100					1	1080												
bay goby	2	36-74													1	74	1	36								
giant kelpfish	2	84-85									1	85											1	84		
lingcod	2	101-130											2	101-130												
vermilion rockfish	2	36-62					1	62							1	36										
black surfperch	1	70													1	70										
brown rockfish	1	65													1	65										
c-o turbot	1	190															1	190								
hornyhead turbot	1	78																			1	78				
night smelt	1	70	1	70																						
sarcastic fringehead	1	101																							1	101
snubnose pipefish	1	110																							1	110
spotted turbot	1	121	1	121																						
Total	1,395		184	34-200	63	37-750	182	30-1100	89	35-520	137	22-373	133	23-1080	182	23-825	163	28-301	27	32-181	27	44-395	111	36-195	97	25-244

Table I-5d. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1995.

Common Name	1995 Total	1995 Range	Station 5: 1995													
			Jan		Feb		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
staghorn sculpin	1,914	46-198	88	62-171	14	92-181	205	54-198	276	46-134	1212	65-139	114	69-122	5	108-120
shiner surfperch	268	42-159	25	78-131	57	89-159	56	86-145	86	42-137	20	78-123	12	72-109	12	82-124
speckled sanddab	248	32-127	136	35-127	53	52-107	31	32-105	3	77-91					25	52-89
English sole	213	25-100			1	41			20	25-60	189	40-89			3	70-100
northern anchovy	182	41-91			5	45-52			66	50-71	6	41-65	2	64	103	67-91
bay goby	154	35-102	40	35-101			112	42-102			1	92	1	92		
arrow goby	86	30-60					86	30-60								
bay pipefish	86	65-249	74	65-249	1	110	10	96-215							1	165
plainfin midshipman	42	28-174									2	160-174	38	28-46	2	41-44
California tonguefish	35	35-98	2	35-59	3	46-50	22	52-61	7	67-82			1	98		
night smelt	31	52-99	14	61-99	1	65							1	58	15	52-68
dwarf surfperch	13	59-148	3	75-105	7	115-148	2	116-135			1	59				
California halibut	11	47-376	2	253-342	2	256-262	5	47-183					2	149-376		
topsmelt	9	75-182	8	165-182									1	75		
tubesnout	7	34-151	6	34-151	1	141										
black surfperch	6	55-305	1	146			2	177-305	3	55-75						
bonyhead sculpin	4	77-107	3	77-100	1	107										
round stingray	4	360-401							1	360	3	362-401				
horn shark	2	750-790	2	750-790												
white surfperch	2	81-82							2	81-82						
bat ray	1	320									1	320				
bocaccio	1	100											1	100		
grey smoothound	1	335									1	335				
hornyhead turbot	1	73													1	73
jacksmelt	1	275			1	275										
leopard shark	1	232									1	232				
queenfish	1	92							1	92						
sand sole	1	158	1	158												
spotted cusk-eel	1	100	1	100												
starry flounder	1	392									1	392				
thornback	1	486									1	486				
vermilion rockfish	1	35			1	35										
white croaker	1	40									1	40				
Total	3,330	25-790	406	34-790	148	35-275	531	30-305	465	25-360	1440	40-486	173	28-376	167	41-165

Table I-5e. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1996.

Common Name	Station 5: 1996	
	Apr	
	Count	Range
staghorn sculpin	536	40-110
English sole	232	21-78
shiner surfperch	25	101-146
California halibut	8	72-350
speckled sanddab	3	48-52
bat ray	2	405-660
horn shark	2	750-794
northern anchovy	1	43
thornback	1	493
California tonguefish	1	58
Total	811	21-794

Table I-5f. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1997.

Common Name	Station 5: 1997	
	Oct	
	Count	Range
speckled sanddab	9	60-103
bay goby	2	37-47
bay pipefish	1	184
snubnose pipefish	1	73
California tonguefish	1	86
Total	14	

Table I-5g. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1998.

Common Name	1998 Total	1998 Range	Station 5: 1998											
			Jan		Mar		May		Jul		Sep		Nov	
			Count	Range	Count	Range	Count	Range	Count	Range	Count	Range	Count	Range
English sole	216	34-120			1	120	27	34-68	187	45-80	1	76		
staghorn sculpin	170	63-164			5	63-164	39	74-116	120	69-111	4	99-105	2	118-127
speckled sanddab	141	36-140	5	46-73	5	46-94	7	64-140	121	71-104	1	82	2	36-48
shiner surfperch	108	38-151	1	97	25	80-147	35	38-134	39	40-151	8	79-116		
northern anchovy	90	40-70			7	46-70	3	40-48	80	41-66				
California halibut	36	50-345	1	119	18	92-200	5	175-239	6	233-345	5	50-315	1	345
round stingray	27	303-420			24	303-420			1	388	1	305	1	392
Pacific herring	23	29-66			21	29-41	2	56-66						
California tonguefish	18	43-79			15	43-73	1	79	2	72				
white croaker	14	26-42					9	26-42	5	30-40				
bat ray	11	597-1150					8	597-1150	3	775-838				
bay goby	9	31-66	3	53-63	2	51-66			1	47			3	31-39
kelp bass	9	36-103	5	42-65	3	46-103							1	36
topsmelt	7	111-201					6	111-201			1	200		
leopard shark	4	231-730					1	231	3	625-730				
thornback	4	466-631					2	466-631	2	525-620				
bay pipefish	3	84-167	1	126									2	84-167
white surfperch	2	190-206									2	190-206		
dwarf surfperch	1	126			1	126								
Gibbonsia spp.	1	81	1	81										
jacksmelt	1	40					1	40						
plainfin midshipman	1	139					1	139						
queenfish	1	117							1	117				
shovelnose guitarfish	1	1050			1	1050								
Total	898		17	42-126	128	29-1050	147	26-1150	571	30-838	23	50-315	12	31-392

Table I-5h. CDFG otter trawl survey counts and length ranges (mm) of fishes collected at station 5 during 1999.

Common Name	1999 Total	1999 Range	Station 5: 1999							
			Jan		Mar		May		Jul	
			Count	Range	Count	Range	Count	Range	Count	Range
staghorn sculpin	261	36-169	1	62	15	36-165	123	66-169	122	75-128
speckled sanddab	91	37-97	13	37-52	29	41-76	26	43-72	23	56-97
shiner surfperch	69	39-146			4	134-140	53	54-146	12	39-125
Pacific herring	56	28-47			56	28-47				
English sole	47	34-94			10	34-49	37	50-94		
northern anchovy	33	22-84			27	22-55	5	47-77	1	84
California halibut	25	119-643			8	119-540	14	125-643	3	219-505
bay pipefish	10	100-224	2	111-200			2	100-166	6	134-224
leopard shark	7	233-734					4	233-734	3	266-268
shovelnose guitarfish	6	623-1350	2	623-1060	2	1030-1035			2	633-1350
arrow goby	5	45-55	1	49	1	45	3	53-55		
bat ray	4	602-710			1	602	2	665-710	1	625
pile surfperch	4	75-302			1	302	3	75-124		
bay goby	3	20-144					2	105-144	1	20
horn shark	3	733-774			1	735			2	733-774
jacksmelt	2	302-340			2	302-340				
plainfin midshipman	2	46-201			1	46	1	201		
queenfish	2	72-83					2	72-83		
round stingray	2	290-350	2	290-350						
starry flounder	2	451-594	2	451-594						
topsmelt	2	90-98					2	90-98		
white surfperch	2	44-79					2	44-79		
black surfperch	1	61					1	61		
c-o turbot	1	68			1	68				
diamond turbot	1	230							1	230
lingcod	1	116							1	116
Syngnathus exilis	1	223							1	223
thornback	1	622					1	622		
vermilion rockfish	1	46			1	46				
Total	645	20-1350	23	37-1060	160	22-1035	283	43-734	179	20-1350

Table I-6a. Summary of fishes collected in CDFG otter trawl surveys: 1992.

Common Name	1992 Total	1992: Month / Station																					
		Mar		Apr					May					Jun					Jul				
		2	3	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
speckled sanddab	3,726	16	58	14	27	72	13	15	70	50	64	29	27	77	96	85	24	24	50	64	89	34	29
bay pipefish	484	3	10	4	14	22	1		28	18	3	1	5	49	21	3		2	21	7	3	1	1
staghorn sculpin	475					1	25	32	12	8	2	61	44	11	8	10	62	46	8	3	2	32	32
northern anchovy	456				91	5	12	3					345										
shiner surfperch	159						24	45				2	6		12	1	34	9	1			16	8
English sole	146						20	12	2	8		37	26	1	1		10	2	3	1			
cabezon	68				1	3			6	1	7	1		9		4			4		1		
California halibut	60			1			2						3				5	5	1			2	7
California tonguefish	31							2				3	6				4	6				4	5
bay goby	30						5	4				2	1					2	2				10
round stingray	28							1				1											
sarcastic fringehead	24	1				9					3				1	6							
spotfin surfperch	18								1	2					14				1				
plainfin midshipman	15															1							3
tubesnout	13			2															1				
white croaker	9						7	2															
striped kelpfish	8									1				1									
California lizardfish	6									1		2					2						1
sand sole	6									1										2			
bat ray	5						2	1										1			1		
black surfperch	5																					4	
pricklebreast poacher	5																		4				
C-O turbot	4											1											
Pacific sardine	4						4																
Poacher, unidentified	4													4									
diamond turbot	3																						
horn shark	3												1										
rubberlip surfperch	2																	1		1			
spotted turbot	2										1												
white surfperch	2					1												1					
big skate	1			1																			
bocaccio	1																						
bonyhead sculpin	1																						
gopher rockfish	1																						
kelp clingfish	1				1																		
lingcod	1	1																					
shovelnose guitarfish	1																1						
starry flounder	1																						
thornback	1																					1	
Grand Total	5,810	21	68	22	134	113	115	117	119	90	80	140	464	152	153	110	142	99	96	78	96	94	96

Table I-6a (continued). Summary of fishes collected in CDFG otter trawl surveys: 1992.

Common Name	1992: Month / Station																								
	Aug					Sep					Oct					Nov					Dec				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
speckled sanddab	87	165	99	24	16	61	336	376	31	16	86	184	313	83	71	56	97	235	75	33	16	24	128	60	27
bay pipefish	27	13	15	4	16	9	7	26		7	14	38	10	2	6	6	6	12	7	11	1	4	12	5	9
staghorn sculpin	5	6	2	4	9	3	7	8	6		2		3	16	3	2									
northern anchovy																									
shiner surfperch					1																				
English sole	1	3					2	2						1	5			1	5	1				2	
cabezon	17		4			5	1	2					2												
California halibut		1		3	7	4	1			3	1	1		1	6	1			4		1				
California tonguefish					1																				
bay goby			1	2				1																	
round stingray																5	1			1	18	1			
sarcastic fringehead		1	1										1											1	
spotfin surfperch																									
plainfin midshipman	1						1			1			1	1					3						3
tubesnout		3					5					1			1										
white croaker																									
striped kelpfish	2					4																			
California lizardfish																									
sand sole											1					2									
bat ray																									
black surfperch					1																				
pricklebreast poacher											1														
c-o turbot			2					1																	
Pacific sardine																									
Poacher, unidentified																									
diamond turbot															1			1	1						
horn shark																			2						
rubberlip surfperch																									
spotted turbot													1												
white surfperch																									
big skate																									
bocaccio						1																			
bonyhead sculpin							1																		
gopher rockfish									1																
kelp clingfish																									
lingcod																									
shovelnose guitarfish																									
starry flounder																	1								
thornback																									
Grand Total	140	192	124	37	51	87	361	416	38	27	105	224	331	104	93	72	105	249	97	46	36	29	140	68	39

Table I-6b. Summary of fishes collected in CDFG otter trawl surveys: 1993.

Common Name	Grand Total	1993: Month / Station																						
		Jan				Feb				Mar					Apr					Jun				
		2	3	4	5	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
speckled sanddab	1888	32	85	82	38	5	25	51	41	1	13	23	21	41	1	5	9	7	7	1	23	69	5	15
English sole	445			1												2		10	4	1	93	31	58	23
bay pipefish	308	1	5	5	24	2	1	8	6		3	4	4	7					2		1	1	1	1
California halibut	76				1			2	4				4	13				5	1				1	1
plainfin midshipman	72		1	10	1		1																	
staghorn sculpin	59		1	6	8			2					2	5			1		1			1	7	4
California tonguefish	57			5	3			8	6			2	3	17										1
grass rockfish	18																							
tubesnout	18	2	2	1			2	1				1					1		1					
topsmelt	15			15																				
round stingray	13								2					1				1						
spotfin surfperch	11																							
cabezon	9															1	3					1		
lingcod	9																							
diamond turbot	8									1			1					1						
horn shark	7			4					1					1					1					
shiner surfperch	7			1															1					
bay goby	6				2								1											
brown rockfish	5																							
sarcastic fringehead	5			1		1																3		
c-o turbot	4						1																	
shovelnose guitarfish	4			1																				
thornback	4																						1	1
white surfperch	4		1		1																			
bat ray	3																						1	1
rubberlip surfperch	3																							
sand sole	3						1																	
giant kelpfish	2										2													
northern anchovy	2																		2					
pile surfperch	2													2										
seniorita	2										2													
starry flounder	2													1										
arrow goby	1																						1	
black surfperch	1				1																			
bonyhead sculpin	1																							
kelp bass	1				1																			
pricklebreast poacher	1																							
spotted cusk-eel	1			1																				
spotted turbot	1																							
Rockfish, unidentified	1																						1	
walleye surfperch	1																							
Grand Total	3,080	35	95	133	80	8	31	72	60	2	20	30	36	88	1	8	14	24	20	2	117	106	76	47

Table I-6b (continued). Summary of fishes collected in CDFG otter trawl surveys: 1993.

Common Name	1993: Month / Station																												
	Jul					Aug					Sep					Oct					Nov					Dec			
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	2	3	4	5
speckled sanddab	6	5	75	1	12	11	43	25	6	21	19	55	18	4	30	38	196	67	11	37	50	40	93	25	49	88	148	61	54
English sole	7	22	25	42	21	7	60	3	4	1		5	2	1	2		2	2	7	4	1			2		1		1	
bay pipefish		3	4	2	2	22	8	10	4	9	8	11	8	1	5	4	2	20	6	6	7	2	10	12	40	5	15	3	3
California halibut			1	1	3				1	2				1	8	1	1		3	8				6	4			1	3
plainfin midshipman									1	1					5		4		2	5				9	18	3	8		3
staghorn sculpin	1			9		1			3	2								2	1	1					1				
California tonguefish				4					2	2					3		1												
grass rockfish			2	3	1			6	3	3																			
tubesnout						3												1					1			1	1		
topsmelt																													
round stingray				1	3					2							1		1	1									
spotfin surfperch						11																							
cabezon								3										1											
lingcod			1					4				1	3																
diamond turbot	1										1				1		1						1						
horn shark																													
shiner surfperch				3	1																		1						
bay goby					1																				2				
brown rockfish				2						2								1											
sarcastic fringehead																													
c-o turbot																											2		1
shovelnose guitarfish					1					1										1									
thornback									1					1															
white surfperch						1		1																					
bat ray					1																								
rubberlip surfperch								3																					
sand sole	1					1																							
giant kelpfish																													
northern anchovy																													
pile surfperch																													
seniorita																													
starry flounder																				1									
arrow goby																													
black surfperch																													
bonyhead sculpin																													1
kelp bass																													
pricklebreast poacher						1																							
spotted cusk-eel																													
spotted turbot																									1				
Rockfish, unidentified																													
walleye surfperch						1																							
Grand Total	16	30	108	68	46	59	111	55	25	46	28	72	31	8	54	43	208	94	31	64	58	42	106	54	115	98	174	66	65

Table I-6c. Summary of fishes collected in CDFG otter trawl surveys: 1994.

Common Name	1994 Total	1994: Month / Station																							
		Jan				Feb				Mar				Apr				May				Jun			
		2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
speckled sanddab	7,833	318	427	215	167	154	221	170	55	152	88	51	92	386	173	19	42	736	272	17	35	514	240	12	26
English sole	642			2		1					1	5	21		1	4	8	68	8	22	51	32	6	40	70
staghorn sculpin	548				3		1	2				12	1			27	1	8	7	50	17	17	7	67	10
bay pipefish	255	3	5	9	5	4	3	4	3		7		1	4	7	2			4	3	4	2	12	1	1
California tonguefish	226			3	3		1		2			15	58			20	33		1	17	24		1	10	16
lingcod	154	1								1									5			42	19	1	2
California halibut	100											5	6			10	4			13	4			22	4
cabezon	74	1	1			2								2				1	12	1		6	18	1	
Syngnathus exilis	45																								
tubesnout	43		1											3											
plainfin midshipman	39		1	8	4														1		1	4	3	1	
shiner surfperch	34																					18	5	1	2
vermilion rockfish	15	1									1	2	1		2							2	4		
horn shark	8			1				1	2				1												1
night smelt	8				1	1						6													
round stingray	8								1							2	1	1						1	
sarcastic fringehead	8						1								1										
c-o turbot	5		1					1								1									
snubnose pipefish	5																								
striped kelpfish	5																								
bonyhead sculpin	4																								
giant kelpfish	4																				1				
grass rockfish	4																						1		
black surfperch	3																		1						
diamond turbot	3											1												1	
spotted turbot	3				1							1													
bat ray	2												1												1
bay goby	2																								
curlfin turbot	2																								
northern anchovy	2																							1	
white surfperch	2																					2			
barred sand bass	1											1													
brown rockfish	1																								
hornyhead turbot	1																								
jack mackerel	1																					1			
penpoint gunnel	1																								
rockweed gunnel	1																								
rubberlip surfperch	1																								
sand sole	1																								
shovelnose guitarfish	1			1																					
spearnose poacher	1																						1		
starry flounder	1																							1	
stripetail rockfish	1																						1		
Grand Total	10,098	324	436	239	184	162	227	178	63	153	97	99	182	395	184	85	89	814	311	123	137	640	318	160	133

Table I-6c (continued). Summary of fishes collected in CDFG otter trawl surveys: 1994.

Common Name	1994: Month / Station																							
	Jul				Aug				Sep				Oct				Nov				Dec			
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
speckled sanddab	639	220	62	54	368	178	26	48	390	72	10	19	72	50	16	20	322	254	102	79	50	33	97	70
English sole	28		43	51	81	1	17	36	22	1	12	2	3		3	1			1					
staghorn sculpin	32	16	78	37	6	7	47	63	7	3	13	2											3	4
bay pipefish	2	7	3	21		1	2	1	5	13	7	1	7	14			5	28	5	27	3	5	6	8
California tonguefish		2	12	3				4																1
lingcod	28	12	1		15	7			12	4			2	1								1		
California halibut			5	3			3	7			8	1			2	3								
cabezon	6	6			3	3			1	5			1	2				1			1			
Syngnathus exilis					5	13			13	7	1		3					1			2			
tubesnout										1										1	29		1	7
plainfin midshipman						1					1	2			1			1		3	2			5
shiner surfperch	1			3	2			2																
vermilion rockfish		1		1																				
horn shark				2																				
night smelt																								
round stingray																2								
sarcastic fringehead		3			2																			1
c-o turbot								1						1										
snubnose pipefish						4																		1
striped kelpfish				4													1							
bonyhead sculpin									1	2								1						
giant kelpfish			1																	1	1			
grass rockfish						3																		
black surfperch				1						1														
diamond turbot																			1					
spotted turbot									1															
bat ray																								
bay goby				1				1																
curlfin turbot					2																			
northern anchovy		1																						
white surfperch																								
barred sand bass																								
brown rockfish				1																				
hornyhead turbot																1								
jack mackerel																								
penpoint gunnel																					1			
rockweed gunnel																	1							
rubberlip surfperch			1																					
sand sole																	1							
shovelnose guitarfish																								
spearnose poacher																								
starry flounder																								
stripetail rockfish																								
Grand Total	736	268	206	182	484	218	95	163	452	109	52	27	88	68	22	27	330	286	109	111	89	39	107	97

Table I-6d. Summary of fishes collected in CDFG otter trawl surveys: 1995.

Common Name	1995 Total	1995: Month / Station																											
		Jan				Feb				Mar				May				Jul				Sep				Nov			
		2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
staghorn sculpin	3,908			1	88		2	17	14	1		84	205	14	17	440	276	57	20	1,084	1,212	19	3	235	114				5
speckled sanddab	1,708	115	31	41	136	67	63	65	53	318	204	9	31	96	169	2	3	28	6			114	38	1		35	51	7	25
northern anchovy	1,030							48	5			5					66			143	6			652	2				103
shiner surfperch	707		1	2	25		25	82	57	8	11	27	56			74	86	1	159	36	20			13	12				12
English sole	508			1		1		3	1	4	3			9	4	6	20	100	21	109	189	21		11		1		1	3
bay goby	249				40					1	9	81	112					2		1	1				1	1			
arrow goby	213											127	86																
bay pipefish	106		2		74	4		2	1			11	10													1			1
California tonguefish	71				2			1	3	6	9	10	22		2	1	7		4	2			1		1				
plainfin midshipman	52																			6	2		1	1	38			2	2
dwarf surfperch	45				3			28	7			3	2							1	1								
night smelt	38			1	14			1	1																1			5	15
California halibut	28			1	2			1	2		1	2	5		3	1				4				1	2			3	
white surfperch	13		2				6			1	1					1	2												
black surfperch	12			1	1		1	2			1		2		1		3												
tubesnout	11	3		1	6				1																				
bonyhead sculpin	9			1	3		1	3	1																				
topsmelt	9				8																				1				
pile surfperch	8						3												5										
starry flounder	8											1		1					1	1	1	1		1				1	
Syngnathus exilis	8										1			1	1								1			3	1		
round stingray	7																1			2	3							1	
sand sole	7	1		1	1					1	2															1			
cabezon	6					1				1	1								1				2						
horn shark	5			1	2			1												1									
spotted cusk-eel	5				1					1	3																		
bat ray	4							1												2	1								
lingcod	4	1					1							1									1						
sarcastic fringehead	4			1							1				2														
leopard shark	3															1				1	1								
c-o turbot	2											1			1														
jacksmelt	2			1					1																				
Pacific herring	2											2																	
thornback	2																			1	1								
walleye surfperch	2															1			1										
barred sand bass	1	1																											
bocaccio	1																								1				
diamond turbot	1										1																		
gopher rockfish	1																					1							
grey smoothound	1																				1								
hornyhead turbot	1																												1
California killifish	1											1																	
California lizardfish	1																	1											
queenfish	1																1												
rubberlip surfperch	1																			1									
spearnose poacher	1		1																										
Pacific tomcod	1																	1											
vermilion rockfish	1								1																				
white croaker	1																				1								
Grand Total	8,810	121	37	54	406	73	102	255	148	342	248	364	531	122	200	527	465	190	218	1395	1440	156	47	915	173	42	52	20	167

Table I-6d. Summary of fishes collected in CDFG otter trawl surveys: 1996.

Common Name	1996 Total	1996: Month / Station			
		Apr			
		2	3	4	5
English sole	1,009	75	21	681	232
staghorn sculpin	748	10	4	198	536
speckled sanddab	174	137	32	2	3
northern anchovy	105	41	50	13	1
shiner surfperch	40	1	3	11	25
California halibut	23			15	8
white surfperch	10	2	6	2	
Pacific herring	9	7	1	1	
cabezon	4	3	1		
bat ray	2				2
bay goby	2	2			
horn shark	2				2
bay pipefish	1		1		
diamond turbot	1			1	
pile surfperch	1		1		
swell shark	1	1			
Syngnathus exilis	1		1		
thornback	1				1
California tonguefish	1				1
white croaker	1			1	
Grand Total	2,136	279	121	925	811

Table I-6e. Summary of fishes collected in CDFG otter trawl surveys: 1997.

Common Name	1997 Total	1997: Month / Station	
		Oct	
		4	5
speckled sanddab	26	17	9
bay pipefish	4	3	1
round stingray	4	4	
bay goby	2		2
California halibut	2	2	
snubnose pipefish	1		1
staghorn sculpin	1	1	
starry flounder	1	1	
Syngnathus exilis	1	1	
California tonguefish	1		1
Grand Total	43	29	14

Table I-6f. Summary of fishes collected in CDFG otter trawl surveys: 1998.

Common Name	1998 Total	1998: Month / Station																							
		Jan				Mar				May				Jul				Sep				Nov			
		2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
shiner surfperch	763		4		1	12	102	196	25	34	215	20	35	29	38	3	39			2	8				
speckled sanddab	470	23	8	5	5	27	19	19	5	52	19	2	7	2	3		121	27	11	2	1	39	64	7	2
staghorn sculpin	463							40	5	3	1	36	39	6	2	198	120	1		4	4	2			2
English sole	317							1	1	31	3	15	27	13	3	27	187	3	1	1	1		1	2	
California halibut	117				1			58	18		1	8	5		1	5	6	1		5	5			2	1
northern anchovy	106								7			16	3				80								
California tonguefish	70			1		2	7	9	15	4	3	17	1		1	8	2								
round stingray	54							7	24							3	1				1			17	1
Pacific herring	38							15	21				2												
bat ray	21									1	1	5	8			3	3								
kelp bass	17			8	5				3																1
white croaker	16											1	9			1	5								
bay pipefish	15		1	2	1		1			1	3								1				3		2
topsmelt	15							1				2	6		1	4					1				
bay goby	10				3				2	1							1								3
pile surfperch	9		4			1	1				1			2											
plainfin midshipman	8									1	1	2	1		1			1				1			
thornback	7												2		1	2	2								
white surfperch	7	1	1							1				2							2				
black surfperch	6										6														
leopard shark	6											1	1			1	3								
sarcastic fringehead	2									2															
Spotted scorpionfish	2					2																			
shovelnose guitarfish	2								1											1					
spotted cusk-eel	2									2															
starry flounder	2						1	1																	
dwarf surfperch	1								1																
Gibbonsia spp.	1				1																				
grass rockfish	1															1									
jacksmelt	1												1												
lingcod	1													1											
California lizardfish	1																						1		
queenfish	1																1								
rubberlip surfperch	1										1														
sand sole	1									1															
snubnose pipefish	1			1																					
Grand Total	2,555	24	18	17	17	44	131	347	128	134	255	125	147	55	51	256	571	33	13	15	23	42	69	28	12

Table I-6g. Summary of fishes collected in CDFG otter trawl surveys: 1999.

Common Name	1999 Total	1999: Month / Station															
		Jan				Mar				May				Jul			
		2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
speckled sanddab	1,154	7	37		13	22	35	14	29	230	361	76	26	134	145	2	23
Pacific herring	672							574	56	39	3						
staghorn sculpin	467			1	1		2	8	15	1	4	56	123	22	25	87	122
English sole	327							5	10	121	52	58	37	39	5		
northern anchovy	223			2			1	181	27	1		5	5				1
shiner surfperch	196							2	4	1	34	6	53		71	13	12
lingcod	99									18	4			69	7		1
California halibut	50		4	2			1	5	8			8	14		1	4	3
vermilion rockfish	34					7	14		1	1	11						
pile surfperch	20								1				3	7	9		
cabezon	17										13			4			
bay pipefish	16				2								2			6	6
California tonguefish	16										7				9		
kelp greenling	12													12			
bat ray	8								1			2	2			2	1
leopard shark	8												4			1	3
shovelnose guitarfish	8				2				2		1	1					2
starry flounder	7			1	2			2				1				1	
arrow goby	6				1				1			1	3				
white surfperch	6										1		2	1	2		
queenfish	5											3	2				
diamond turbot	4		2	1													1
horn shark	4			1					1								2
plainfin midshipman	4								1	1	1		1				
thornback	4												1		3		
bay goby	3												2				1
black surfperch	3												1	1	1		
topsmelt	3											1	2				
black rockfish	2															2	
bocaccio	2													1	1		
grass rockfish	2										1	1					
jacksmelt	2								2								
round stingray	2				2												
sand sole	2		1				1										
Syngnathus exilis	2															1	1
c-o turbot	1								1								
gunnel, unidentified	1									1							
night smelt	1															1	
rainbow surfperch	1													1			
rockpool blenny	1										1						
turbot, unidentified	1										1						
Grand Total	3,396	7	44	8	23	29	54	791	160	414	495	219	283	291	279	120	179

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix I

Part 2

PFMC Commercial Landings for 1999

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	All Wash. Ports	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	ARROWTOOTH FLOUNDER	655.3	395.2	.2	37.0	47.4	3.1	6.2	3.0	.1	ARTH
	BUTTER SOLE	.0	.1			.2		.0			BSOL
	CURLFIN SOLE		.3	.1	.9	.6	.1				CSOL
	DOVER SOLE	578.3	1,372.6	19.1	504.8	1,070.3	291.5	434.2	795.6	524.1	DOVR
	ENGLISH SOLE	140.0	86.0	.8	33.5	104.8	15.8	63.1	56.0	49.4	EGLS
	FLATHEAD SOLE		2.2								FSOL
	PETRALE SOLE	552.6	458.0	14.4	272.5	583.4	91.0	181.9	404.5	142.3	PTRL
	REX SOLE	17.6	65.7	.1	26.8	96.6	15.9	46.7	65.7	61.3	REX
	ROCK SOLE	.3	.1	.1	1.3	1.8	.0			.3	RSOL
	SAND SOLE	.8	57.3	12.8	17.4	44.5	.1	6.9	.6		SSOL
	SANDDABS	.2	5.7	1.4	3.2	125.4	2.4	53.6	67.5	2.0	SDAB
	STARRY FLOUNDER	.3	10.0	.9	2.0	4.9	.0	4.8	2.9	.0	STRY
	OTHER FLATFISH										OFLT
	UNSP. FLATFISH	7.0						.5	1.0	.0	UFLT
2	__ALL FLATFISH	1,952.5	2,453.2	50.0	899.3	2,079.8	419.9	797.8	1,396.8	779.6	FLAT
1	LONGSPINE THORNYHEA	45.6	343.5		130.2	427.1	125.3	274.7	523.4	332.4	LSPN
	NOM. LONGSPINE THOR	.0	35.4		49.9	28.3	.4		.2	.6	LSP1
	NOM. SHORTSPINE THO	28.5	26.8	.0	18.8	8.6	.7		12.8	1.7	SSP1
	SHORTSPINE THORNYHE	75.0	187.5		149.3	183.6	78.9	120.0	230.2	154.4	SSPN
	THORNYHEADS (MIXED)				.0	.0	.0	5.5	17.4	31.3	THDS
4	__THORNYHEADS COMPL	149.1	593.2	.0	348.2	647.6	205.3	400.2	784.0	520.3	TRNY
1	NOM. SHORTBELLY ROC							.5	.7		SBL1
	NOM. WIDOW ROCKFISH	.1	116.4	.1	65.5	60.2	48.2	1.0	3.0	.9	WDW1
	NOMINAL POP		69.0	.0	3.5	6.2	.2				POP2
	PACIFIC OCEAN PERCH	129.1	124.6	.0	57.3	9.0	1.2	.0	.4		POP
	SHORTBELLY ROCKFISH					.0	.0		.3	.1	SBLY
	UNSP. POP GROUP	.0									UPOP
	WIDOW ROCKFISH	428.7	672.4		971.1	294.1	107.6	102.6	121.9	115.1	WDOW
	AURORA ROCKFISH	.1	.5	.0	2.4	1.9	.5	1.0	.5	.1	ARRA
	BANK ROCKFISH		.0	.0	3.0	1.2	.7	.2	1.4	4.2	BANK
	BLACK ROCKFISH						84.7	55.5	15.5	8.8	BLCK
	BLACK+BLUE ROCKFISH							.1	.1		RCK9
	BLACK-AND-YELLOW RO									26.8	BYEL
	BLACKGILL ROCKFISH	2.3	.0		.9	2.5	.6	.2	.4	.7	BLGL
	BLUE ROCKFISH						4.0	7.3	3.5	7.2	BLUR
	BOCACCIO	8.7	3.3	.7	19.3	3.0	12.3	4.8	18.0	13.0	BCAC
	BRONZESPOTTED ROCKF								.2		BRNZ
	BROWN ROCKFISH							1.1		.3	BRWN
	CALIFORNIA SCORPION										SCOR
	CANARY ROCKFISH	98.8	72.0		124.3	55.7	84.4	22.6	39.8	29.3	CNRY
	CANARY+VERMILION RC										RCK8
	CHAMELEON ROCKFISH										CMEL
	CHILIPEPPER	.2				1.4	.1	4.2	19.8	322.8	CLPR
	CHINA ROCKFISH					.2	121.2	13.1	2.7	19.5	CHNA
	COPPER ROCKFISH						21.9	15.7	31.4	13.0	COPP
	COWCOD ROCKFISH					1.9	.1				CWCD
	DARKBLOTCHED ROCKFI	8.6	38.5	.3	53.5	84.4	11.0	14.7	31.5	3.8	DBRK

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	All Wash. Ports	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	FLAG ROCKFISH										FLAG
	GOPHER ROCKFISH									38.3	GPHR
	GRASS ROCKFISH							1.5		33.6	GRAS
	GREENBLOTCHED ROCKF										GBLC
	GREENSPOTTED ROCKFI							.3	2.6	2.6	GSPT
	GREENSTRIPED ROCKFI	3.1	4.6	.1	1.7	12.7	1.2	4.3	1.6	1.1	GSRK
	HALFBANDED ROCKFISH							.5			HBRK
	HONEYCOMB ROCKFISH										HNYC
	KELP ROCKFISH								.0	.1	KLPR
	MEXICAN ROCKFISH										MXRF
	NOM. BANK ROCKFISH										BNK1
	NOM. BLACK ROCKFISH		3.4	45.5	1.1	1.3	25.9	.2	.3	.1	BLK1
	NOM. BLACK-AND-YELL							.0	.0	.2	BYL1
	NOM. BLACKGILL ROCK							.4		.2	BGL1
	NOM. BLUE ROCKFISH							9.2	3.9	.0	BLU1
	NOM. BOCACCIO							.1	.3	.0	BCC1
	NOM. BROWN ROCKFISH								2.3	.6	BRW1
	NOM. CANARY ROCKFIS	6.3	51.7	2.7	35.0	61.7	30.0	1.4	1.3	.4	CNR1
	NOM. CHILIPEPPER							.5	.3	2.4	CLP1
	NOM. CHINA ROCKFISH							.3	.0	.5	CHN1
	NOM. COPPER ROCKFIS							.0	.3		COP1
	NOM. COWCOD ROCKFIS								.0		CWC1
	NOM. DARKBLOTCHED R							.0			DBR1
	NOM. FLAG ROCKFISH										FLG1
	NOM. GOPHER ROCKFIS							.1	.0	.7	GPH1
	NOM. GRASS ROCKFISH								1.5	.0	GRS1
	NOM. GREENSPOTTED R								.1	.1	GSP1
	NOM. GREENSTRIPED R							.0			GSR1
	NOM. KELP ROCKFISH									.1	KLP1
	NOM. OLIVE ROCKFISH							.5	.2		OLV1
	NOM. QUILLBACK ROCK							.2	8.7	.0	QLB1
	NOM. REDBANDED ROCK								.1		RDB1
	NOM. ROSETHORN ROCK							.4	.1	.1	RST1
	NOM. ROSY ROCKFISH										ROS1
	NOM. SPECKLED ROCKF										SPK1
	NOM. SPLITNOSE ROCK							.1	4.1	.0	SNS1
	NOM. SQUARESPOT										SQR1
	NOM. STARRY ROCKFIS										STR1
	NOM. SWORDSPINE ROC										SWS1
	NOM. TREEFISH										TRE1
	NOM. VERMILLION ROC							.3	.0	1.0	VRM1
	NOM. YELLOWEYE ROCK							.2	.4	.8	YEY1
	NOM. YELLOWTAIL ROC	37.1	339.4	3.1	38.0	40.3	17.2	.9	.0	.1	YTR1
	OLIVE ROCKFISH										OLVE
	PINK ROCKFISH										PNKR
	PYGMY ROCKFISH										PGMY
	QUILLBACK ROCKFISH					.0	25.1	18.2	.5	14.2	QLBK
	REDBANDED ROCKFISH	10.3	2.9	.0	1.7	3.6	1.0	1.4	1.8	.4	RDBD
	REDSTRIPE ROCKFISH	6.0	2.3	.0	3.6	7.4	1.4	.3	.7	.0	REDS
	ROSETHORN ROCKFISH	.0	.2		.1	.8	3.2	.3	.5	.0	RSTN
	ROSY ROCKFISH							.2		.0	ROSY

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	All Wash. Ports	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	ROUGHEYE ROCKFISH	15.8	12.8	.0	8.0	9.5	24.0		.0		REYE
	SHARPCHIN ROCKFISH	4.6	10.8	.0	2.5	2.7	.2	3.9	9.4	.1	SHRP
	SHORTRAKER ROCKFISH	11.3	26.8	.0	3.8	1.7	1.2				SRKR
	SILVERGREY ROCKFISH	22.1	23.6	.0	17.4	1.0	.2	.0	.0	.0	SLGR
	SPECKLED ROCKFISH								.0	.0	SPKL
	SPLITNOSE ROCKFISH	.7	6.3	.2	9.3	8.0	1.6	10.4	4.6	17.7	SNOS
	STARRY ROCKFISH									.0	STAR
	STRIPETAIL ROCKFISH		.0			.2	1.3	1.9	1.7	1.0	STRK
	TIGER ROCKFISH	.1	.1		.1	.1	5.1	.2			TIGR
	TREEFISH										TREE
	UNSP. BOLINA RCKFSH							.1		.0	RCK2
	UNSP. GOPHER RCKFSH									.0	RCK7
	UNSP. REDS RCKFSH							1.2	1.4	.3	RCK4
	UNSP. ROSEFISH RCKF								.3	13.2	RCK6
	UNSP. SMALL REDS RC							1.6	.7	2.4	RCK5
	VERMILION ROCKFISH					.1	34.3	5.9	3.6	7.7	VRML
	YELLOWEYE ROCKFISH	8.5	1.3	.0	44.0	55.4	74.2	12.8	10.3	9.1	YEYE
	YELLOWMOUTH ROCKFIS	3.9	2.5	.0	14.6	.1	.0		.1		YMTH
	YELLOWTAIL ROCKFISH	410.3	555.7	1.0	193.8	127.0	55.1	37.8	28.9	8.9	YTRK
	OTHER ROCKFISH				1.0	1.2	6.7				ORCK
	GEN. SHELF/SLOPE RF		5.9	1.3	14.6	5.1	5.6				POP1
	UNSP. NEAR-SHORE RO										USHR
	UNSP. ROCKFISH	318.6	137.1	.6	13.5	33.7	22.8	3.4	.8	.6	URCK
2	__ALL ROCKFISH	1,684.6	2,877.6	55.6	2,053.0	1,543.0	1,041.3	766.0	1,168.4	1,244.9	ROCK
1	CABEZON			1.7	7.2	.2	89.7	18.1	11.0	216.0	CBZN
	KELP GREENLING							27.0	3.7	57.6	KLPG
	LINGCOD	53.3	61.6	11.1	53.6	58.0	105.4	58.0	41.2	56.9	LCOD
	NOM. CABEZON							.1	.1	1.4	CBZ1
	NOM. KELP GREENLING							.9	.0	.8	KGL1
	PACIFIC COD	226.6	36.0		.4	.8	.0	.0			PCOD
	PACIFIC WHITING	802.5	3,169.8		2,537.9	204.3	.7	104.3	11.0		PWHT
	SABLEFISH	5,059.9	2,429.4	3.4	2,412.0	1,978.7	871.1	590.6	1,192.3	858.7	SABL
	WALLEYE POLLOCK	.0	.0		.0						PLCK
2	__ALL ROUNDFISH	6,142.3	5,696.8	16.2	5,011.0	2,241.9	1,066.9	799.1	1,259.2	1,191.4	ROND
1	LEOPARD SHARK								3.0		LSRK
	SOUPFIN SHARK	.2	.0		.6	.2	.1	.2	.5	.6	SSRK
	SPINY DOGFISH	137.1	15.2	.0	.0	.0		.0	.5		DSRK
	RATFISH				.0			.0			RATF
	BIG SKATE										BSKT
	CALIFORNIA SKATE										CSKT
	OTHER GROUNDFISH		.0		.7						OGRN
	UNSP. GRENADIERS		2.6		2.2	17.5	4.4	3.3	20.6	10.0	GRDR
	UNSPECIFIED SKATE	27.8	37.5	.2	27.8	62.8	18.5	98.7	108.6	32.9	USKT
2	__MISC. GROUNDFISH	165.2	55.3	.2	31.4	80.5	23.0	102.2	133.2	43.6	MGRN
3	__ALL GROUNDFISH	9,944.6	11,083.0	122.0	7,994.6	5,945.3	2,551.2	2,465.2	3,957.6	3,259.4	GRND

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	All Wash. Ports	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	CALIFORNIA HALIBUT				.0	.1		10.7	2.3		CHLB
	PACIFIC HALIBUT	618.3	74.9	39.8	130.9	52.3	37.5	.1	1.5	6.5	PHLB
	PINK SHRIMP	1,212.5	2,631.1	357.7	2,927.7	2,822.7	831.7	1,215.2	445.5	149.7	PSHP
	UNSPECIFIED OCTOPI	1.3	.6		1.8	.3	2.7	.7	.2	.1	OCTP
4	__ALL SHARKS	294.6	18.2	.0	1.4	.3	.1	3.6	4.1	.9	SHRK
	__ALL SKATES & RAYS	27.8	37.5	.2	27.8	62.8	18.5	98.7	109.4	32.9	SKAT
1	UNSPECIFIED SCULPIN				.0		.0			.0	SCLP
	UNSPECIFIED SMELT	.1						51.9	114.4	2.3	SMLT
	UNSPECIFIED SQUID	.1	.0		.0	.0		.1			SQID

152 rows selected.

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	ARROWTOOTH FLOUNDER	.0	1.0	.0						.2	1,148.6	ARTH
	BUTTER SOLE		.0								.3	BSOL
	CURLFIN SOLE						.1				1.9	CSOL
	DOVER SOLE	169.6	178.6	347.8	337.4	.2	.1	.0			6,624.1	DOVR
	ENGLISH SOLE	10.7	72.5	35.2	7.1	.1					675.2	EGLS
	FLATHEAD SOLE										2.2	FSOL
	PETRALE SOLE	46.9	204.7	143.2	40.3	3.0	.1	.0			3,139.0	PTRL
	REX SOLE	11.0	22.8	26.3	10.1	.0	.2				466.7	REX
	ROCK SOLE	.1	5.5	.4							9.9	RSOL
	SAND SOLE	.7	36.1	1.6	.8			.2			179.7	SSOL
	SANDDABS	.4	381.5	122.6	11.6	1.2	25.8	1.6			806.1	SDAB
	STARRY FLOUNDER	1.1	21.1	3.8	2.0						53.9	STRY
	OTHER FLATFISH		.4		.1	.0				.1	.6	OFLT
	UNSP. FLATFISH	.1	12.8	2.7	2.0	7.3	13.5	.2			47.2	UFLT
2	__ALL FLATFISH	240.7	937.0	683.6	411.4	11.9	39.7	1.9		.3	13,155.4	FLAT
1	LONGSPINE THORNYHEAD	62.7	82.9	215.5	188.5	1.3	59.5				2,812.4	LSPN
	NOM. LONGSPINE THORNY	2.3	1.1	.2	3.5	10.4	.7	8.4			141.4	LSP1
	NOM. SHORTSPINE THORN	1.5	4.3	.1	.4	18.9	8.9	3.3			135.1	SSP1
	SHORTSPINE THORNYHEAD	30.1	37.7	374.3	92.6		154.9	28.9			1,897.3	SSPN
	THORNYHEADS (MIXED)	5.5	9.1	6.8		11.4	1.1	1.3		.0	89.5	THDS
4	__THORNYHEADS COMPLEX	102.1	135.1	596.8	285.0	41.9	225.0	41.9		.0	5,075.7	TRNY
1	NOM. SHORTBELLY ROCKF										1.1	SBL1
	NOM. WIDOW ROCKFISH	29.3	32.9	2.9		1.0	.3	.5			362.4	WDW1
	NOMINAL POP										79.0	POP2
	PACIFIC OCEAN PERCH		.6							2.6	324.9	POP
	SHORTBELLY ROCKFISH			.0							.5	SBLY
	UNSP. POP GROUP										.0	UPOP
	WIDOW ROCKFISH	97.0	63.4	42.4	22.7	.0	.4	.0		23.0	3,062.4	WDOW
	AURORA ROCKFISH	.3	1.0	2.2	5.4						16.0	ARRA
	BANK ROCKFISH	3.2	16.6	13.2	13.3	1.0	1.5	4.0			63.7	BANK
	BLACK ROCKFISH	.1	5.7	.3	.8						171.5	BLCK
	BLACK+BLUE ROCKFISH		.3								.4	RCK9
	BLACK-AND-YELLOW ROCK			84.9	97.4						209.0	BYEL
	BLACKGILL ROCKFISH	1.2	3.5	16.0	16.5	9.3	11.8	26.0			92.0	BLGL
	BLUE ROCKFISH	.7	13.0	2.9	40.3	1.5	.1				80.6	BLUR
	BOCACCIO	18.6	27.5	25.2	11.1	8.4	3.7	2.3		.3	180.2	BCAC
	BRONZESPOTTED ROCKFIS		2.0		.0	.3	.8	.0			3.3	BRNZ
	BROWN ROCKFISH	13.2	98.3	6.5	148.6		.0				268.0	BRWN
	CALIFORNIA SCORPIONFI			.1	.0	93.2	103.4	7.2			203.9	SCOR
	CANARY ROCKFISH	15.8	12.5	7.7	5.4	.8	2.0	1.1		3.6	575.8	CNRY
	CANARY+VERMILION RCKF		.1								.1	RCK8
	CHAMELEON ROCKFISH		.0				.0	.1			.2	CMEL
	CHILIPEPPER	136.4	248.2	146.0	35.8	17.8	1.9	.3			935.0	CLPR
	CHINA ROCKFISH	1.2	5.2	4.2	.7						168.0	CHNA
	COPPER ROCKFISH	9.9	15.9	6.2	9.0	2.0	1.9	.1			127.1	COPP
	COWCOD ROCKFISH	.5	2.0	1.5	1.1	1.6	1.1	.1			9.9	CWCD
	DARKBLOTCHED ROCKFISH	2.0	3.2	2.5	.6						254.7	DBRK

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	FLAG ROCKFISH		.1	.3	.1	.2	1.0				1.7	FLAG
	GOPHER ROCKFISH	1.4	4.0	37.6	176.1	.3	.0				257.7	GPHR
	GRASS ROCKFISH	13.7		31.2	165.4						245.3	GRAS
	GREENBLOTCHED ROCKFIS	.2	.9	.2	.0	.4	1.2	.2			3.0	GBLC
	GREENSPOTTED ROCKFISH	3.6	7.0	4.9	2.5	4.2	6.5	.1			34.1	GSPT
	GREENSTRIPED ROCKFISH	.2	.3	.4	.0	1.1	.6				33.1	GSRK
	HALFBANDED ROCKFISH										.5	HBRK
	HONEYCOMB ROCKFISH							.0			.0	HNYC
	KELP ROCKFISH			10.0	12.5						22.6	KLPR
	MEXICAN ROCKFISH	.0					.3	.2			.5	MXRF
	NOM. BANK ROCKFISH	.0	1.6	2.3				.1			4.0	BNK1
	NOM. BLACK ROCKFISH	1.2	1.0	.1	.0			.0			80.2	BLK1
	NOM. BLACK-AND-YELLOW	1.2	.4								1.8	BYL1
	NOM. BLACKGILL ROCKFI	.3	.9	2.2	.0	18.3	.1				22.3	BGL1
	NOM. BLUE ROCKFISH	1.2	.0	.1	.1	.2	.0				14.7	BLU1
	NOM. BOCACCIO		1.3	4.9	.2	.6	4.1	3.2			14.8	BCC1
	NOM. BROWN ROCKFISH	.2	9.6	3.0		4.4					20.1	BRW1
	NOM. CANARY ROCKFISH	4.3	4.4								199.3	CNR1
	NOM. CHILIPEPPER		3.6	4.3	3.4	6.6	3.9	4.6			29.6	CLP1
	NOM. CHINA ROCKFISH	1.6	2.1	.1	.0	1.6					6.3	CHN1
	NOM. COPPER ROCKFISH	21.2	23.2	.1	.6	5.9	.1				51.4	COP1
	NOM. COWCOD ROCKFISH		.2	.2	.7	.2	4.4	2.9			8.7	CWC1
	NOM. DARKBLOTCHED ROC		.0	.3							.4	DBR1
	NOM. FLAG ROCKFISH			.0							.0	FLG1
	NOM. GOPHER ROCKFISH	.9	6.6	4.6	.8	28.2	.2	.0			42.2	GPH1
	NOM. GRASS ROCKFISH	.0	.5		.3	49.3					51.7	GRS1
	NOM. GREENSPOTTED ROC		4.1	5.0	.0	.3					9.5	GSP1
	NOM. GREENSTRIPED ROC		.9	.1		.0	.1				1.1	GSR1
	NOM. KELP ROCKFISH	.0	.0		.1	1.3					1.5	KLP1
	NOM. OLIVE ROCKFISH			.0	.0	.8	.5				2.0	OLV1
	NOM. QUILLBACK ROCKFI	1.0	33.9	.0							43.8	QLB1
	NOM. REDBANDED ROCKFI										.1	RDB1
	NOM. ROSETHORN ROCKFI		.2	.0	.0	.1					.9	RST1
	NOM. ROSY ROCKFISH		.2	.0		.0					.2	ROS1
	NOM. SPECKLED ROCKFIS	1.2	.0				5.5				6.7	SPK1
	NOM. SPLITNOSE ROCKFI	.0	.1			.0	2.4	.0			6.8	SNS1
	NOM. SQUARESPOT			.0							.0	SQR1
	NOM. STARRY ROCKFISH			.0		2.9	.1	.1			3.1	STR1
	NOM. SWORDSPINE ROCKF			.2							.2	SWS1
	NOM. TREEFISH			.1		.8	.0	.0			.9	TRE1
	NOM. VERMILLION ROCKF	.8	8.6	2.8	1.3	1.3	.0	1.8			17.9	VRM1
	NOM. YELLOWEYE ROCKFI	.3	3.7	1.6							7.0	YEY1
	NOM. YELLOWTAIL ROCKF	.0	2.0	1.8		.6	.3	.2			480.9	YTR1
	OLIVE ROCKFISH	.1	.5	1.7	.7	1.1	.9	.1			5.2	OLVE
	PINK ROCKFISH			.0		.2	.6	.0			.9	PNKR
	PYGMY ROCKFISH			.0	.0						.0	PGMY
	QUILLBACK ROCKFISH	.1	1.4	2.6							62.1	QLBK
	REDBANDED ROCKFISH	.7	1.0	.1	.4						25.3	RDBD
	REDSTRIPE ROCKFISH										21.7	REDS
	ROSETHORN ROCKFISH		.1	.1			.2				5.5	RSTN
	ROSY ROCKFISH	.9	1.0	.4	.0		.1				2.6	ROSY

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	ROUGHEYE ROCKFISH			.6	.0						70.8	REYE
	SHARPCHIN ROCKFISH	.3	.1	.1							34.8	SHRP
	SHORTRAKER ROCKFISH										44.8	SRKR
	SILVERGREY ROCKFISH	.2									64.7	SLGR
	SPECKLED ROCKFISH	.1	1.2	1.0	.4	2.3	.9	.4			6.3	SPKL
	SPLITNOSE ROCKFISH	4.9	27.0	35.4	12.6	.3	.6	.9			140.7	SNOS
	STARRY ROCKFISH	1.8	1.5	3.1	1.4	1.9	5.4	.2			15.3	STAR
	STRIPETAIL ROCKFISH	.1	.1	.0							6.4	STRK
	TIGER ROCKFISH	.0									5.6	TIGR
	TREEFISH				7.2	2.2	.1				9.5	TREE
	UNSP. BOLINA RCKFSH	.6	.9	1.2	1.7	4.5					9.1	RCK2
	UNSP. GOPHER RCKFSH	6.1	3.9		.1	8.3					18.4	RCK7
	UNSP. REDS RCKFSH	.0	1.5	.5	3.1	32.4	.5	.5			41.4	RCK4
	UNSP. ROSEFISH RCKFSH	.0	.5	.4	.0	.0					14.5	RCK6
	UNSP. SMALL REDS RCKF	1.4	9.8	3.0	.1	.2	.0	.2			19.3	RCK5
	VERMILION ROCKFISH	2.4	3.7	12.1	29.0	11.7	33.8	3.7			148.1	VRML
	YELLOWEYE ROCKFISH	2.2	2.7	3.0	1.7	.3	.8				226.3	YEYE
	YELLOWMOUTH ROCKFISH										21.3	YMTH
	YELLOWTAIL ROCKFISH	26.0	31.0	9.0	3.0	2.8	.2			372.0	1,862.5	YTRK
	OTHER ROCKFISH									14.7	23.6	ORCK
	GEN. SHELF/SLOPE RF										32.5	POP1
	UNSP. NEAR-SHORE ROCK		.5								.5	USHR
	UNSP. ROCKFISH	.2	.2	3.2	1.7	30.9	.5	1.5			569.3	URCK
2	__ALL ROCKFISH	534.4	897.2	1,157.4	1,121.0	407.4	430.0	104.7		416.2	17,502.7	ROCK
1	CABEZON	28.5	.1	80.4	471.9						924.8	CBZN
	KELP GREENLING	.1	.1	12.7	19.8						121.0	KLPG
	LINGCOD	12.7	42.2	25.8	38.5	6.9	1.6	.8		.0	627.5	LCOD
	NOM. CABEZON		4.1	.1	.2	140.6	.5	.2			147.3	CBZ1
	NOM. KELP GREENLING	5.0	.3	5.1	.0	.1	.2				12.4	KGL1
	PACIFIC COD									.0	263.9	PCOD
	PACIFIC WHITING		.0	.3		.0	.0			11,811.7	18,642.4	PWHT
	SABLEFISH	207.3	274.5	682.0	129.9	36.7	246.6	85.0		.7	17,058.8	SABL
	WALLEYE POLLOCK										.0	PLCK
2	__ALL ROUNDFISH	253.7	321.3	806.4	660.3	184.3	248.8	86.0		11,812.5	37,798.2	ROND
1	LEOPARD SHARK	.1	6.6	1.1	.1	6.8	6.5	1.2			25.5	LSRK
	SOUPFIN SHARK	.1	4.7	8.8	1.6	30.9	21.9	33.5			104.1	SSRK
	SPINY DOGFISH			9.7		.2	5.2	.0			168.0	DSRK
	RATFISH	.2									.2	RATF
	BIG SKATE		.5								.5	BSKT
	CALIFORNIA SKATE		.0					.0			.1	CSKT
	OTHER GROUNDFISH									25.0	25.7	OGRN
	UNSP. GRENADIERS	1.7	1.3	45.1	3.2						112.0	GRDR
	UNSPECIFIED SKATE	2.0	18.3	19.4	1.7	.3	6.8	.3			463.7	USKT
2	__MISC. GROUNDFISH	4.1	31.4	84.1	6.6	38.2	40.4	35.0		25.0	899.6	MGRN
3	__ALL GROUNDFISH	1,032.9	2,186.9	2,731.5	2,199.3	641.7	759.0	227.7		12,254.1	69,355.8	GRND

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PFMC Port Group Report: Estimated Ex-vessel Revenue ($1000) of Groundfish Landed-catch for 1999 for all Areas for all Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	CALIFORNIA HALIBUT	55.4	1,056.5	369.4	189.7	813.1	675.5	115.5			3,288.2	CHLB
	PACIFIC HALIBUT						.2				962.1	PHLB
	PINK SHRIMP	28.0		3.0	195.5	4.8					12,825.0	PSHP
	UNSPECIFIED OCTOPI	.4	.9	1.8	.1	.4	1.0	.0			12.1	OCTP
4	__ALL SHARKS	.5	14.4	58.2	34.0	168.0	260.1	269.4			1,127.9	SHRK
	__ALL SKATES & RAYS	2.0	18.8	19.4	1.8	15.3	11.6	.5			485.1	SKAT
1	UNSPECIFIED SCULPIN	1.6	6.4	.0							8.1	SCLP
	UNSPECIFIED SMELT	.2	.1	.7		.0	1.7				171.5	SMLT
	UNSPECIFIED SQUID			.3	.0	.0	4.5				4.9	SQID

152 rows selected.

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea
2. Port group "WA Coast" consists of all Washington ports on the Columbia River and the Pacific Coast

T	Species or Group	No Puget	South Puget	WA Coast	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	ARROWTOOTH FLOUNDER	2,545.4		418.9	1,854.8	1.0	194.3	214.1	13.6	27.9	13.1	.5	ARTH
	BUTTER SOLE			.0	.1			.4		.0			BSOL
	CURLFIN SOLE				.4	.1	1.2	.9	.1				CSOL
	DOVER SOLE	421.9		383.9	1,884.0	24.0	733.5	1,475.6	396.3	569.5	1,065.0	709.3	DOVR
	ENGLISH SOLE	145.9		32.4	124.2	1.1	51.8	148.5	23.1	83.8	74.4	65.5	EGLS
	FLATHEAD SOLE				3.0								FSOL
	PETRALE SOLE	182.9		74.0	209.2	6.4	132.4	281.8	44.6	94.5	210.3	70.6	PTRL
	REX SOLE	6.9		15.6	85.4	.2	36.7	138.9	20.7	54.8	77.2	71.5	REX
	ROCK SOLE	.3		.1	.2	.1	1.9	2.2	.0			.4	RSOL
	SAND SOLE	.1		.4	34.4	7.7	10.5	26.5	.1	4.3	.3		SSOL
	SANDDABS	.1		.3	8.3	2.0	5.6	254.0	3.5	75.6	95.6	2.9	SDAB
	STARRY FLOUNDER	.2		.3	11.9	1.3	2.7	5.9	.0	5.4	3.2	.0	STRY
	OTHER FLATFISH												OFLT
	UNSP. FLATFISH	8.7		.6						.6	1.3	.0	UFLT
2	__ALL FLATFISH	3,312.3		926.4	4,215.9	43.8	1,170.8	2,548.7	502.0	916.4	1,540.3	920.7	FLAT
1	LONGSPINE THORNYHEA				230.0		86.2	252.9	84.9	156.4	305.5	182.5	LSPN
	NOM. LONGSPINE THOR				23.6		33.6	17.2	.3		.1	.4	LSP1
	NOM. SHORTSPINE THO				14.4	.0	10.1	4.4	.3		5.3	.7	SSP1
	SHORTSPINE THORNYHE				99.6		77.3	91.0	36.6	52.3	98.9	64.2	SSPN
	THORNYHEADS (MIXED)						.0	.0	.0	2.9	8.2	14.9	THDS
4	__THORNYHEADS COMPL				367.5	.0	207.2	365.5	122.1	211.6	418.1	262.5	TRNY
1	NOM. SHORTBELLY ROC									5.5	2.5		SBL1
	NOM. WIDOW ROCKFISH				140.6	.1	84.4	71.1	54.5	1.2	3.4	.2	WDW1
	NOMINAL POP				78.5	.0	4.1	7.1	.1				POP2
	PACIFIC OCEAN PERCH				142.3	.0	78.2	12.3	1.5	.1	.5		POP
	SHORTBELLY ROCKFISH							.1	.0		.5	.2	SBLY
	UNSP. POP GROUP												UPOP
	WIDOW ROCKFISH				798.1		1,145.6	348.8	126.4	121.0	140.1	132.6	WDOW
	AURORA ROCKFISH				.7	.0	3.0	2.5	.8	1.6	.9	.2	ARRA
	BANK ROCKFISH				.0	.0	3.8	1.4	.8	.2	1.6	4.8	BANK
	BLACK ROCKFISH								64.9	34.5	12.5	4.6	BLCK
	BLACK+BLUE ROCKFISH									.0	.0		RCK9
	BLACK-AND-YELLOW RO											2.7	BYEL
	BLACKGILL ROCKFISH				.0		1.1	2.8	.6	.2	.4	.8	BLGL
	BLUE ROCKFISH								2.4	4.4	2.5	3.5	BLUR
	BOCACCIO				3.8	.4	19.2	2.7	4.2	5.4	20.5	14.6	BCAC
	BRONZESPOTTED ROCKF										.3		BRNZ
	BROWN ROCKFISH									.3		.0	BRWN
	CALIFORNIA SCORPION												SCOR
	CANARY ROCKFISH				76.7		102.7	55.8	46.4	23.8	41.9	22.7	CNRY
	CANARY+VERMILION RC												RCK8
	CHAMELEON ROCKFISH												CMEL
	CHILIPEPPER							1.9	.2	6.0	25.4	372.3	CLPR
	CHINA ROCKFISH							.0	24.1	1.7	.5	2.1	CHNA
	COPPER ROCKFISH								4.5	5.6	11.6	3.6	COPP

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea
2. Port group "WA Coast" consists of all Washington ports on the Columbia River and the Pacific Coast

T	Species or Group	No Puget	South Puget	WA Coast	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	COWCOD ROCKFISH							2.2	.1				CWCD
	DARKBLOTCHED ROCKFI				50.1	.3	68.0	109.2	13.5	20.8	40.7	4.3	DBRK
	FLAG ROCKFISH												FLAG
	GOPHER ROCKFISH											3.8	GPHR
	GRASS ROCKFISH									.1		3.2	GRAS
	GREENBLOTCHED ROCKF												GBLC
	GREENSPOTTED ROCKFI									.3	2.4	2.0	GSPT
	GREENSTRIPED ROCKFI				7.6	.1	2.4	19.7	1.6	7.0	2.5	1.5	GSRK
	HALFBANDED ROCKFISH									.6			HBRK
	HONEYCOMB ROCKFISH												HNYC
	KELP ROCKFISH										.0	.0	KLPR
	MEXICAN ROCKFISH												MXRF
	NOM. BANK ROCKFISH												BNK1
	NOM. BLACK ROCKFISH				3.3	35.6	.7	1.1	19.3	.1	.3	.1	BLK1
	NOM. BLACK-AND-YELL									.0	.0	.0	BYL1
	NOM. BLACKGILL ROCK									.2		.2	BGL1
	NOM. BLUE ROCKFISH									5.6	2.2	.0	BLU1
	NOM. BOCACCIO									.1	.3	.0	BCC1
	NOM. BROWN ROCKFISH										.5	.1	BRW1
	NOM. CANARY ROCKFIS				55.6	1.9	36.0	33.8	15.3	1.6	.8	.5	CNR1
	NOM. CHILIPEPPER									.6	.3	2.5	CLP1
	NOM. CHINA ROCKFISH									.0	.0	.0	CHN1
	NOM. COPPER ROCKFIS									.0	.1		COP1
	NOM. COWCOD ROCKFIS										.0		CWC1
	NOM. DARKBLOTCHED R									.4			DBR1
	NOM. FLAG ROCKFISH												FLG1
	NOM. GOPHER ROCKFIS									.0	.0	.1	GPH1
	NOM. GRASS ROCKFISH										.2	.0	GRS1
	NOM. GREENSPOTTED R										.1	.1	GSP1
	NOM. GREENSTRIPED R									.0			GSR1
	NOM. KELP ROCKFISH											.0	KLP1
	NOM. OLIVE ROCKFISH									.1	.2		OLV1
	NOM. QUILLBACK ROCK									.0	1.6	.0	QLB1
	NOM. REDBANDED ROCK										.1		RDB1
	NOM. ROSETHORN ROCK									.1	.1	.0	RST1
	NOM. ROSY ROCKFISH												ROS1
	NOM. SPECKLED ROCKF												SPK1
	NOM. SPLITNOSE ROCK									.0	6.2	.0	SNS1
	NOM. SQUARESPOT												SQR1
	NOM. STARRY ROCKFIS												STR1
	NOM. SWORDSPINE ROC												SWS1
	NOM. TREEFISH												TRE1
	NOM. VERMILLION ROC									.0	.0	1.0	VRM1
	NOM. YELLOWEYE ROCK									.0	.3	.5	YEY1
	NOM. YELLOWTAIL ROC				452.2	2.7	53.2	34.7	14.0	1.0	.0	.0	YTR1
	OLIVE ROCKFISH												OLVE
	PINK ROCKFISH												PNKR
	PYGMY ROCKFISH												PGMY
	QUILLBACK ROCKFISH							.0	5.1	3.3	.4	1.6	QLBK

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea
2. Port group "WA Coast" consists of all Washington ports on the Columbia River and the Pacific Coast

T	Species or Group	No Puget	South Puget	WA Coast	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	REDBANDED ROCKFISH				3.4	.0	2.1	4.4	1.0	1.7	2.3	.4	RDBD
	REDSTRIPE ROCKFISH				3.7	.1	4.4	11.9	2.3	.5	.9	.0	REDS
	ROSETHORN ROCKFISH				.4		.1	1.2	1.5	.4	.7	.0	RSTN
	ROSY ROCKFISH									.3		.0	ROSY
	ROUGHEYE ROCKFISH				14.7	.0	9.6	11.0	6.9		.0		REYE
	SHARPCHIN ROCKFISH				17.2	.0	3.4	4.3	.3	6.4	14.6	.1	SHRP
	SHORTRAKER ROCKFISH				30.4	.0	4.6	1.9	1.4				SRKR
	SILVERGREY ROCKFISH				26.8	.0	19.6	1.1	.2	.1	.0	.1	SLGR
	SPECKLED ROCKFISH										.0	.0	SPKL
	SPLITNOSE ROCKFISH				9.0	.3	12.1	11.3	2.4	18.9	7.2	26.0	SNOS
	STARRY ROCKFISH											.0	STAR
	STRIPETAIL ROCKFISH				.0			.3	2.3	3.0	2.8	1.5	STRK
	TIGER ROCKFISH				.1		.1	.1	1.1	.0			TIGR
	TREEFISH												TREE
	UNSP. BOLINA RCKFSH									.0		.0	RCK2
	UNSP. GOPHER RCKFSH											.0	RCK7
	UNSP. REDS RCKFSH									.7	1.2	.1	RCK4
	UNSP. ROSEFISH RCKF										.1	21.4	RCK6
	UNSP. SMALL REDS RC									1.9	.8	.5	RCK5
	VERMILION ROCKFISH							.0	7.3	1.8	1.3	2.2	VRML
	YELLOWEYE ROCKFISH				1.5	.0	24.5	20.8	16.1	3.5	3.2	2.7	YEYE
	YELLOWMOUTH ROCKFIS				2.8	.0	18.8	.1	.0		.1		YMTH
	YELLOWTAIL ROCKFISH				632.6	.9	221.1	144.7	57.0	38.9	28.7	8.3	YTRK
	OTHER ROCKFISH						.5	.7	1.7				ORCK
	GEN. SHELF/SLOPE RF				9.9	1.2	25.1	8.0	7.3				POP1
	UNSP. NEAR-SHORE RO												USHR
	UNSP. ROCKFISH				129.1	.4	16.5	24.1	7.2	3.4	.9	.4	URCK
2	__ALL ROCKFISH	988.8	2.8	826.4	3,058.5	44.0	2,171.8	1,318.6	638.5	546.8	807.2	912.6	ROCK
1	CABEZON					.8	2.3	.2	23.2	3.5	2.7	30.0	CBZN
	KELP GREENLING									3.3	.5	6.9	KLPG
	LINGCOD	27.5	.4	13.8	45.8	5.9	38.4	40.5	43.2	32.6	26.6	29.7	LCOD
	NOM. CABEZON									.0	.0	.2	CBZ1
	NOM. KELP GREENLING									.5	.0	.1	KGL1
	PACIFIC COD	229.0		13.1	36.4		.6	.7	.0	.0			PCOD
	PACIFIC WHITING	7.5		9,091.2	38,304.3		31,650.9	2,997.3	1.6	1,187.2	120.0		PWHT
	SABLEFISH	866.2	124.3	709.5	943.7	1.7	888.9	785.0	352.2	303.9	518.7	410.9	SABL
	WALLEYE POLLOCK			.2	.0		.0						PLCK
2	__ALL ROUNDFISH	1,130.1	124.7	9,827.9	39,330.3	8.4	32,581.0	3,823.7	420.2	1,531.1	668.6	477.7	ROND
1	LEOPARD SHARK										1.4		LSRK
	SOUPFIN SHARK	.2		.0	.2		.4	.1	.1	.1	.2	.5	SSRK
	SPINY DOGFISH	381.4		19.7	75.3	.0	13.5	.1		.0	.7		DSRK
	RATFISH						.0			.0			RATF
	BIG SKATE												BSKT
	CALIFORNIA SKATE												CSKT
	OTHER GROUNDFISH				.0		.5						OGRN

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea
2. Port group "WA Coast" consists of all Washington ports on the Columbia River and the Pacific Coast

T	Species or Group	No Puget	South Puget	WA Coast	Col R OR.	Tillamook	Newport	Coos Bay	Brookings	Crescent City	Eureka	Fort Bragg	SPID
1	UNSP. GRENADIERS				12.1		12.5	78.9	20.4	14.4	87.6	43.7	GRDR
	UNSPECIFIED SKATE	68.5		56.6	130.5	.4	139.5	262.8	57.0	308.8	342.6	100.7	USKT
2	__MISC. GROUNDFISH	450.1		76.4	218.2	.4	166.3	341.9	77.5	323.4	432.5	144.9	MGRN
3	__ALL GROUNDFISH	5,881.4	127.5	11,657.1	46,822.8	96.7	36,089.9	8,032.9	1,638.2	3,317.7	3,448.6	2,456.0	GRND
1	CALIFORNIA HALIBUT						.0	.0		2.4	.5		CHLB
	PACIFIC HALIBUT	89.7		42.8	20.2	10.0	34.1	11.8	9.6	.0	.4	1.7	PHLB
	PINK SHRIMP	11.4		1,192.6	2,626.7	362.0	2,795.3	2,700.3	792.2	1,186.7	437.9	144.5	PSHP
	UNSPECIFIED OCTOPI	.8		.1	.5		.4	.2	2.6	1.0	.2	.1	OCTP
4	__ALL SHARKS	382.0		90.9	76.8	.0	14.2	.3	.1	2.2	2.3	.7	SHRK
	__ALL SKATES & RAYS	68.5		56.6	130.5	.4	139.5	262.8	57.0	308.8	343.6	100.7	SKAT
1	UNSPECIFIED SCULPIN						.0		.0			.0	SCLP
	UNSPECIFIED SMELT			.1						78.7	172.6	3.4	SMLT
	UNSPECIFIED SQUID	.0		.1	.1		.5	.5		.1			SQID

152 rows selected.

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	ARROWTOOTH FLOUNDER	.1	1.0	.1						1.2	5,286.0	ARTH
	BUTTER SOLE		.0								.5	BSOL
	CURLFIN SOLE						.0				2.7	CSOL
	DOVER SOLE	243.2	294.0	490.2	446.6	.1	.0	.0			9,137.2	DOVR
	ENGLISH SOLE	13.4	93.4	46.4	8.6	.1					912.6	EGLS
	FLATHEAD SOLE										3.0	FSOL
	PETRALE SOLE	20.9	86.9	65.9	16.2	1.4	.1	.0			1,498.1	PTRL
	REX SOLE	12.8	26.5	31.1	11.5	.0	.2				590.0	REX
	ROCK SOLE	.1	5.7	.3							11.3	RSOL
	SAND SOLE	.5	19.5	2.2	.4			.2			107.0	SSOL
	SANDDABS	.6	524.3	203.2	20.6	.6	4.0	.4			1,201.4	SDAB
	STARRY FLOUNDER	1.2	21.2	3.1	.6						56.9	STRY
	OTHER FLATFISH		.3		.0	.0				.1	.4	OFLT
	UNSP. FLATFISH	.2	12.5	1.9	1.2	4.1	10.3	.1			41.5	UFLT
2	__ALL FLATFISH	292.9	1,085.3	844.5	505.8	6.3	14.6	.6		1.3	18,848.6	FLAT
1	LONGSPINE THORNYHEAD	38.5	57.0	121.6	114.7	.2	9.9				1,670.6	LSPN
	NOM. LONGSPINE THORNY	1.2	.7	.0	2.1	3.3	.3	1.5			84.2	LSP1
	NOM. SHORTSPINE THORN	.9	2.4	.0	.2	3.0	1.3	.4			59.0	SSP1
	SHORTSPINE THORNYHEAD	17.0	21.8	101.1	56.1		27.8	4.2			790.0	SSPN
	THORNYHEADS (MIXED)	3.0	5.4	4.0		2.7	.2	.2		.0	41.5	THDS
4	__THORNYHEADS COMPLEX	60.5	87.3	226.7	173.1	9.2	39.4	6.3		.0	2,645.2	TRNY
1	NOM. SHORTBELLY ROCKF										8.0	SBL1
	NOM. WIDOW ROCKFISH	17.8	18.6	2.2		.2	.1	.3			394.7	WDW1
	NOMINAL POP										89.8	POP2
	PACIFIC OCEAN PERCH		1.0							3.0	390.0	POP
	SHORTBELLY ROCKFISH			.0							.8	SBLY
	UNSP. POP GROUP										.1	UPOP
	WIDOW ROCKFISH	101.7	60.0	43.4	25.3	.0	.1	.0		32.8	3,589.9	WDOW
	AURORA ROCKFISH	.6	1.6	3.7	10.2						25.8	ARRA
	BANK ROCKFISH	3.4	15.6	10.1	14.4	.1	.5	1.6			58.4	BANK
	BLACK ROCKFISH	.0	2.2	.2	.3						119.1	BLCK
	BLACK+BLUE ROCKFISH		.2								.2	RCK9
	BLACK-AND-YELLOW ROCK			9.6	12.7						25.0	BYEL
	BLACKGILL ROCKFISH	1.3	3.5	7.7	16.2	1.0	4.5	8.5			51.3	BLGL
	BLUE ROCKFISH	.3	3.4	1.2	5.7	.1	.0				23.7	BLUR
	BOCACCIO	13.2	21.0	19.6	6.1	.9	1.2	.8		.3	143.9	BCAC
	BRONZESPOTTED ROCKFIS		1.9		.0	.0	.2	.0			2.4	BRNZ
	BROWN ROCKFISH	2.6	19.9	1.4	19.4		.0				43.6	BRWN
	CALIFORNIA SCORPIONFI			.0	.0	17.0	20.6	1.8			39.4	SCOR
	CANARY ROCKFISH	7.6	7.2	4.1	1.6	.2	.5	.3		4.1	511.9	CNRY
	CANARY+VERMILION RCKF		.1								.1	RCK8
	CHAMELEON ROCKFISH		.0				.0	.0			.1	CMEL
	CHILIPEPPER	114.1	220.5	138.7	31.4	1.8	.6	.1			913.1	CLPR
	CHINA ROCKFISH	.2	1.4	.7	.1						30.9	CHNA
	COPPER ROCKFISH	2.1	2.8	1.3	2.2	.3	.5	.0			34.5	COPP
	COWCOD ROCKFISH	.6	2.1	1.2	.3	.3	.3	.0			7.0	CWCD
	DARKBLOTCHED ROCKFISH	1.9	3.1	2.8	.6						325.6	DBRK

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	FLAG ROCKFISH		.1	.2	.0	.0	.3				.6	FLAG
	GOPHER ROCKFISH	.3	.8	5.4	23.5	.0	.0				33.8	GPHR
	GRASS ROCKFISH	1.6		3.0	14.8						22.6	GRAS
	GREENBLOTCHED ROCKFIS	.2	.8	.1	.0	.1	.3	.0			1.5	GBLC
	GREENSPOTTED ROCKFISH	2.2	3.5	2.7	.8	.6	1.8	.0			16.3	GSPT
	GREENSTRIPED ROCKFISH	.2	.1	.4	.0	.1	.2				47.1	GSRK
	HALFBANDED ROCKFISH										.6	HBRK
	HONEYCOMB ROCKFISH							.0			.0	HNYC
	KELP ROCKFISH			1.4	1.5						3.0	KLPR
	MEXICAN ROCKFISH	.0					.1	.1			.2	MXRF
	NOM. BANK ROCKFISH	.0	1.2	2.3				.0			3.5	BNK1
	NOM. BLACK ROCKFISH	.8	.4	.1	.0			.0			61.5	BLK1
	NOM. BLACK-AND-YELLOW	.1	.0								.2	BYL1
	NOM. BLACKGILL ROCKFI	.3	.7	1.4	.0	9.5	.0				12.4	BGL1
	NOM. BLUE ROCKFISH	.6	.0	.0	.0	.1	.0				8.5	BLU1
	NOM. BOCACCIO		1.0	4.6	.2	.4	2.1	1.5			10.2	BCC1
	NOM. BROWN ROCKFISH	.0	4.6	2.6		.8					8.6	BRW1
	NOM. CANARY ROCKFISH	1.4	1.2								154.8	CNR1
	NOM. CHILIPEPPER		3.1	4.0	2.5	1.5	1.3	2.6			18.3	CLP1
	NOM. CHINA ROCKFISH	.2	.3	.0	.0	.2					.8	CHN1
	NOM. COPPER ROCKFISH	7.0	5.7	.0	.1	1.1	.0				14.0	COP1
	NOM. COWCOD ROCKFISH		.2	.2	.5	.1	1.1	.9			3.1	CWC1
	NOM. DARKBLOTCHED ROC		.0	.2							.6	DBR1
	NOM. FLAG ROCKFISH			.0							.0	FLG1
	NOM. GOPHER ROCKFISH	.1	.9	.6	.1	3.5	.0	.0			5.2	GPH1
	NOM. GRASS ROCKFISH	.0	.0		.0	4.1					4.3	GRS1
	NOM. GREENSPOTTED ROC		1.6	2.3	.0	.1					4.2	GSP1
	NOM. GREENSTRIPED ROC		.5	.2		.0	.1				.8	GSR1
	NOM. KELP ROCKFISH	.0	.0		.0	.1					.2	KLP1
	NOM. OLIVE ROCKFISH			.0	.0	.1	.2				.6	OLV1
	NOM. QUILLBACK ROCKFI	.1	2.9	.0							4.6	QLB1
	NOM. REDBANDED ROCKFI										.1	RDB1
	NOM. ROSETHORN ROCKFI		.3	.0	.0	.0					.5	RST1
	NOM. ROSY ROCKFISH		.2	.0		.0					.3	ROS1
	NOM. SPECKLED ROCKFIS	.7	.0				1.6				2.3	SPK1
	NOM. SPLITNOSE ROCKFI	.0	.1			.0	.5	.0			7.0	SNS1
	NOM. SQUARESPOT			.0							.0	SQR1
	NOM. STARRY ROCKFISH			.0		1.0	.0	.0			1.0	STR1
	NOM. SWORDSPINE ROCKF			.1							.1	SWS1
	NOM. TREEFISH			.0		.1	.0	.0			.1	TRE1
	NOM. VERMILLION ROCKF	.3	1.9	.9	.2	.4	.0	.6			5.4	VRM1
	NOM. YELLOWEYE ROCKFI	.1	.7	.6							2.2	YEY1
	NOM. YELLOWTAIL ROCKF	.0	1.6	1.6		.1	.2	.1			605.6	YTR1
	OLIVE ROCKFISH	.1	.2	.9	.2	.1	.3	.0			1.9	OLVE
	PINK ROCKFISH			.0		.0	.2	.0			.3	PNKR
	PYGMY ROCKFISH			.0	.0						.0	PGMY
	QUILLBACK ROCKFISH	.0	.3	.5							11.2	QLBK
	REDBANDED ROCKFISH	.5	.7	.1	.2						29.2	RDBD
	REDSTRIPE ROCKFISH										30.9	REDS
	ROSETHORN ROCKFISH		.0	.0			.0				4.4	RSTN
	ROSY ROCKFISH	.3	.4	.2	.0		.0				1.2	ROSY

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	ROUGHEYE ROCKFISH			.1	.0						61.1	REYE
	SHARPCHIN ROCKFISH	.1	.1	.1							51.9	SHRP
	SHORTRAKER ROCKFISH										51.5	SRKR
	SILVERGREY ROCKFISH	.1									74.0	SLGR
	SPECKLED ROCKFISH	.0	.5	.5	.2	.2	.3	.1			1.9	SPKL
	SPLITNOSE ROCKFISH	6.8	44.0	66.0	23.8	.0	.2	.4			229.2	SNOS
	STARRY ROCKFISH	.6	.5	1.2	.4	.3	1.5	.1			4.5	STAR
	STRIPETAIL ROCKFISH	.1	.1	.0							10.2	STRK
	TIGER ROCKFISH	.0									1.5	TIGR
	TREEFISH				.6	.2	.0				.8	TREE
	UNSP. BOLINA RCKFSH	.1	.1	.2	.3	.5					1.3	RCK2
	UNSP. GOPHER RCKFSH	.7	.5		.0	1.1					2.4	RCK7
	UNSP. REDS RCKFSH	.0	.6	.2	1.5	9.5	.1	.2			14.2	RCK4
	UNSP. ROSEFISH RCKFSH	.0	.3	.7	.0	.0					22.6	RCK6
	UNSP. SMALL REDS RCKF	1.9	9.6	4.7	.1	.1	.0	.1			19.7	RCK5
	VERMILION ROCKFISH	.8	1.7	5.9	7.7	2.1	8.6	1.2			40.5	VRML
	YELLOWEYE ROCKFISH	.8	1.2	1.2	.5	.1	.2				86.3	YEYE
	YELLOWMOUTH ROCKFISH										26.6	YMTH
	YELLOWTAIL ROCKFISH	16.0	15.4	4.5	1.6	.3	.1			452.6	2,141.7	YTRK
	OTHER ROCKFISH									12.8	15.7	ORCK
	GEN. SHELF/SLOPE RF										51.5	POP1
	UNSP. NEAR-SHORE ROCK		.1								.1	USHR
	UNSP. ROCKFISH	.2	.1	2.1	.9	9.2	.2	.6			448.4	URCK
2	__ALL ROCKFISH	373.4	584.1	598.8	401.9	79.0	90.4	28.5		505.6	13,977.9	ROCK
1	CABEZON	4.3	.0	10.3	53.7						131.0	CBZN
	KELP GREENLING	.0	.0	1.2	1.8						13.8	KLPG
	LINGCOD	6.1	18.8	12.6	13.1	2.0	.5	.3		.0	357.8	LCOD
	NOM. CABEZON		.8	.1	.0	14.2	.2	.0			15.5	CBZ1
	NOM. KELP GREENLING	.8	.1	.8	.0	.0	.1				2.4	KGL1
	PACIFIC COD									.0	279.8	PCOD
	PACIFIC WHITING		.0	.4		.0	.0			140,024.2	223,384.7	PWHT
	SABLEFISH	93.4	134.3	329.5	85.9	13.2	68.6	15.4		.7	6,646.0	SABL
	WALLEYE POLLOCK										.3	PLCK
2	__ALL ROUNDFISH	104.7	154.2	354.8	154.5	29.4	69.4	15.7		140,024.9	230,831.4	ROND
1	LEOPARD SHARK	.1	3.0	.5	.1	6.1	4.7	.6			16.5	LSRK
	SOUPFIN SHARK	.0	2.8	4.1	2.9	32.2	19.4	25.8			89.0	SSRK
	SPINY DOGFISH			18.7		.3	4.9	.0			514.7	DSRK
	RATFISH	.2									.2	RATF
	BIG SKATE		.6								.6	BSKT
	CALIFORNIA SKATE		.0					.0			.1	CSKT
	OTHER GROUNDFISH									33.4	33.9	OGRN
	UNSP. GRENADIERS	7.0	5.2	142.3	13.1						437.3	GRDR
	UNSPECIFIED SKATE	5.9	24.9	54.6	3.7	.3	15.4	.2			1,572.5	USKT
2	__MISC. GROUNDFISH	13.2	36.5	220.2	19.8	38.9	44.4	26.7		33.4	2,664.7	MGRN
3	__ALL GROUNDFISH	784.2	1,860.1	2,018.3	1,082.0	153.7	218.8	71.5		140,565.2	266,322.6	GRND

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PFMC Port Group Report: Groundfish Landed-catch (Metric tons) for 1999 for All Gears

Notes: 1. Landed-catch excludes any fish discarded at sea

T	Species or Group	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Unkn Cal	WOC at Sea	All Ports	SPID
1	CALIFORNIA HALIBUT	10.9	204.2	88.8	35.7	143.9	99.5	18.8			604.8	CHLB
	PACIFIC HALIBUT						.0				220.3	PHLB
	PINK SHRIMP	25.4		.5	126.1	2.8					12,404.5	PSHP
	UNSPECIFIED OCTOPI	.2	.6	.7	.0	.3	.4	.0			8.1	OCTP
4	__ALL SHARKS	.2	8.1	46.5	26.3	131.6	152.8	151.1			1,086.1	SHRK
	__ALL SKATES & RAYS	5.9	25.5	54.6	3.9	20.6	23.1	.5			1,602.5	SKAT
1	UNSPECIFIED SCULPIN	.2	.7	.0							1.0	SCLP
	UNSPECIFIED SMELT	.1	.1	.5		.0	1.4				256.8	SMLT
	UNSPECIFIED SQUID			.1	.0	.0	6.1				7.5	SQID

152 rows selected.

Morro Bay Power Plant Modernization Project
316(b) Resource Assessment

Appendix I

Part 3

CDFG California Commercial Landings for 1999

California Department of Fish and Game
Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
;hes										
\nchovy, northern	0	0	2,983	99,697	3,291,385	4,459	4,864,347	3,150,550	4,120	11,417,540
	$0	$0	$1,637	$13,015	$219,661	$892	$322,384	$235,213	$665	$793,467
3arracuda, California	331	0	0	264	139	18	2,626	180,546	18,745	202,668
	$397	$0	$0	$108	$113	$8	$1,924	$87,857	$24,278	$114,686
3ass, giant sea	0	0	0	0	0	40	2,437	1,882	640	4,999
	$0	$0	$0	$0	$0	$80	$4,328	$2,767	$1,189	$8,364
3ass, spotted sand	0	0	0	0	0	0	0	0	24	24
	$0	$0	$0	$0	$0	$0	$0	$0	$42	$42
3lacksmith	0	0	0	0	0	0	0	256	0	256
	$0	$0	$0	$0	$0	$0	$0	$366	$0	$366
3onito, Pacific	0	0	0	1	441	0	117,420	72,852	555	191,269
	$0	$0	$0	$0	$798	$0	$13,222	$14,863	$119	$29,002
3utterfish (Pacific pompano)	0	0	0	360	307	0	830	95	0	1,591
	$0	$0	$0	$805	$563	$0	$1,103	$94	$0	$2,565
Cabezon	14,031	67,244	9,492	1,862	23,326	129,423	56,781	360	45	302,563
	$29,447	$220,844	$28,500	$4,122	$77,010	$516,529	$269,186	$454	$47	$1,146,140
Cabrilla, spotted	0	0	0	0	0	0	0	3	0	3
	$0	$0	$0	$0	$0	$0	$0	$5	$0	$5
Cod, Pacific	49	0	0	0	0	0	0	0	0	49
	$22	$0	$0	$0	$0	$0	$0	$0	$0	$22
Corvina, shortfin	0	0	0	58	0	0	0	0	0	58
	$0	$0	$0	$58	$0	$0	$0	$0	$0	$58
Croaker, unspecifed	0	0	0	528	0	0	65	0	0	593
	$0	$0	$0	$189	$0	$0	$49	$0	$0	$238
Croaker, white	0	0	232	29,863	55,496	0	3,622	113,342	507	203,061
	$0	$0	$180	$21,992	$7,861	$0	$2,380	$92,295	$634	$125,342
Croaker, yellowfin	0	0	0	0	0	0	0	0	755	755
	$0	$0	$0	$0	$0	$0	$0	$0	$378	$378

California Department of Fish and Game

Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
ishes										
Dolphin (fish)...........................	0	0	0	0	6,700	1,818	483	22,466	4,329	35,795
	$0	$0	$0	$0	$5,643	$1,808	$362	$32,594	$7,388	$47,796
Eel, California moray...............	0	0	0	0	0	4	0	487	140	631
	$0	$0	$0	$0	$0	$0	$0	$3,284	$1,005	$4,289
Eel, monkeyface.....................	31	0	0	10	60	70	0	0	0	170
	$54	$0	$0	$29	$218	$168	$0	$0	$0	$469
Eel, wolf (wolf-eel)...................	0	0	0	0	4	0	0	0	0	4
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Eel..	0	0	0	0	0	6	0	0	0	6
	$0	$0	$0	$0	$0	$12	$0	$0	$0	$12
Escolar....................................	0	0	0	0	310	0	0	753	2,753	3,816
	$0	$0	$0	$0	$465	$0	$0	$753	$3,236	$4,454
Fish, unspecified.....................	98	0	18	37	18	147	834	8	47	1,208
	$5	$0	$0	$10	$19	$163	$713	$0	$457	$1,367
Flounder, arrowtooth...............	90,463	1,175	220	2,289	154	0	0	0	0	94,301
	$9,128	$119	$22	$971	$15	$0	$0	$0	$0	$10,255
Flounder, starry.......................	18,970	59	2,632	46,683	6,884	1,234	0	0	0	76,462
	$7,702	$24	$1,108	$20,952	$3,233	$2,041	$0	$0	$0	$35,059
Flounder, unspecified.............	0	0	141	24,091	3,380	1,695	7	39	19	29,372
	$0	$0	$56	$11,416	$1,899	$1,229	$6	$93	$28	$14,728
Flyingfish................................	0	0	0	147	110	0	0	0	0	257
	$0	$0	$0	$118	$44	$0	$0	$0	$0	$162
Goby, yellowfin.......................	0	0	0	273	0	0	0	0	0	273
	$0	$0	$0	$743	$0	$0	$0	$0	$0	$743
Greenling, kelp........................	9,481	13,233	1,678	231	4,308	3,229	16	151	0	32,326
	$31,309	$52,146	$4,852	$329	$17,717	$16,785	$79	$227	$0	$123,444
Grenadiers..............................	224,955	96,290	15,460	11,480	313,742	28,915	0	0	0	690,842
	$23,900	$8,450	$1,729	$1,283	$44,733	$3,163	$0	$0	$0	$83,258

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
ishes										
Grouper....................................	0	0	2	0	0	0	0	0	0	2
	$0	$0	$4	$0	$0	$0	$0	$0	$0	$4
Guitarfish, shovelnose............	0	0	0	0	0	231	22,071	14,475	540	37,317
	$0	$0	$0	$0	$0	$101	$12,903	$4,564	$189	$17,756
Halfmoon..................................	0	0	0	0	0	0	28	9	0	37
	$0	$0	$0	$0	$0	$0	$27	$9	$0	$36
Halibut, California....................	6,509	0	24,006	449,195	198,817	77,533	296,944	219,021	41,004	1,313,028
	$13,027	$0	$54,615	$1,053,189	$368,063	$187,792	$809,186	$673,155	$114,589	$3,273,616
Halibut, Pacific........................	826	3,110	0	0	0	0	0	75	0	4,011
	$1,623	$2,894	$0	$0	$0	$0	$0	$207	$0	$4,724
Halibut, unspecified.................	0	0	45	25,835	790	0	12,172	0	50	38,891
	$0	$0	$101	$64,369	$1,580	$0	$28,966	$0	$150	$95,166
Hardhead (freshwater)...........	0	0	0	33	0	0	0	0	0	33
	$0	$0	$0	$17	$0	$0	$0	$0	$0	$17
Herring roe on kelp.................	0	0	0	87,236	0	0	0	0	0	87,236
	$0	$0	$0	$78,348	$0	$0	$0	$0	$0	$78,348
Herring, Roe..........................	38,388	0	104,295	4,881,964	0	0	0	0	0	5,024,647
	$10,657	$0	$39,145	$1,842,734	$0	$0	$0	$0	$0	$1,892,536
Herring, round........................	0	0	0	0	0	0	0	128,138	0	128,138
	$0	$0	$0	$0	$0	$0	$0	$5,126	$0	$5,126
Hitch.....................................	348	0	0	0	0	0	0	0	0	348
	$400	$0	$0	$0	$0	$0	$0	$0	$0	$400
Jack, Pacific crevalle.............	0	0	0	0	0	0	0	204	0	204
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Jacksmelt...............................	0	0	240	118	855	0	0	1,325	0	2,538
	$0	$0	$75	$114	$548	$0	$0	$945	$0	$1,681
Kahawai.................................	0	0	0	0	0	0	0	115	0	115
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
hes										
ingcod	130,389	65,387	12,790	41,481	27,708	28,499	4,471	1,038	684	312,445
	$98,764	$53,962	$12,046	$42,040	$24,659	$37,933	$6,391	$1,419	$835	$278,049
izardfish, California	0	0	0	0	0	0	78	32	0	110
	$0	$0	$0	$0	$0	$0	$26	$5	$0	$31
ouvar	244	0	0	210	426	1,642	642	1,259	4,086	8,509
	$361	$0	$0	$51	$1,106	$5,619	$2,321	$4,453	$12,499	$26,409
lackerel, Pacific	5,645	0	1,477	342	6,033	69	376,893	18,731,666	31,713	19,153,837
	$545	$0	$368	$131	$9,960	$28	$37,091	$1,035,653	$4,564	$1,088,339
lackerel, bullet	0	0	0	0	0	0	0	12,473	0	12,473
	$0	$0	$0	$0	$0	$0	$0	$499	$0	$499
lackerel, jack	1,517	0	41	13	53,308	0	402	2,044,468	125	2,099,874
	$0	$0	$24	$5	$1,747	$0	$19	$182,015	$125	$183,935
lackerel, unspecified	692	0	0	245	0	0	0	0	0	937
	$0	$0	$0	$76	$0	$0	$0	$0	$0	$76
lidshipman, plainfin	0	0	0	0	0	0	78	71	0	149
	$0	$0	$0	$0	$0	$0	$0	$8	$0	$8
ilfish	0	0	0	0	66	432	0	481	278	1,257
	$0	$0	$0	$0	$99	$48	$0	$514	$278	$939
pah	442	0	0	728	4,232	5,850	5,186	19,909	108,600	144,947
	$153	$0	$0	$430	$1,798	$2,730	$2,729	$9,699	$48,576	$66,114
paleye	0	0	0	0	0	9	43	887	0	939
	$0	$0	$0	$0	$0	$7	$86	$1,107	$0	$1,199
ueenfish	0	0	0	0	338	0	0	61	0	399
	$0	$0	$0	$0	$101	$0	$0	$18	$0	$119
atfish, spotted	6	0	409	0	0	0	0	0	0	415
	$12	$0	$151	$0	$0	$0	$0	$0	$0	$163
ay, Pacific electric	0	0	0	0	0	10	822	0	0	832
	$0	$0	$0	$0	$0	$0	$2,075	$0	$0	$2,075

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
ishes										
Ray, bat..................................	2,057	0	0	0	0	0	15	133	0	2,205
	$541	$0	$0	$0	$0	$0	$45	$1	$0	$587
Ray, unspecified....................	0	0	0	141	0	0	0	62	0	203
	$0	$0	$0	$141	$0	$0	$0	$16	$0	$157
Rockfish, China......................	4,872	7,526	442	718	178	210	354	0	0	14,300
	$15,987	$32,738	$1,578	$2,087	$768	$582	$1,630	$0	$0	$55,371
Rockfish, Pacific ocean perch.	1,286	0	0	2,140	0	0	0	0	0	3,426
	$414	$0	$0	$561	$0	$0	$0	$0	$0	$975
Rockfish, bank.......................	0	0	6	13,032	4,984	9,069	0	0	75	27,166
	$0	$0	$5	$6,327	$2,279	$4,133	$0	$0	$81	$12,826
Rockfish, black-and-yellow......	12	5,367	263	92	13,503	4,338	0	0	0	23,575
	$41	$24,814	$1,156	$386	$60,030	$16,134	$0	$0	$0	$102,562
Rockfish, black.......................	105,257	11,058	1,359	11,151	616	587	0	0	9	130,037
	$74,289	$9,245	$1,163	$11,706	$699	$865	$0	$0	$18	$97,984
Rockfish, blackgill..................	523	409	661	6,830	12,634	30,021	21,000	3,559	2,010	77,646
	$431	$167	$284	$3,241	$14,422	$13,720	$17,656	$2,249	$2,416	$54,586
Rockfish, blue........................	17,052	5,015	1,308	2,880	1,707	2,280	110	13	0	30,366
	$13,141	$4,769	$1,129	$2,815	$1,287	$1,253	$160	$20	$0	$24,574
Rockfish, bocaccio.................	22,593	22,120	24,593	26,573	36,016	8,399	966	6,299	3,319	150,878
	$9,129	$7,932	$15,937	$15,709	$15,912	$3,728	$653	$7,411	$3,206	$79,618
Rockfish, brown.....................	1,904	268	85	10,154	5,685	4,156	1,660	0	0	23,911
	$3,331	$603	$155	$9,612	$3,039	$18,357	$4,339	$0	$0	$39,435
Rockfish, canary....................	136,628	43,552	26,407	19,193	5,467	60	912	0	0	232,220
	$73,882	$24,326	$28,404	$21,073	$4,724	$108	$1,502	$0	$0	$154,017
Rockfish, chilipepper..............	18,311	799,700	254,873	472,675	312,753	73,815	3,283	19,606	5,403	1,960,419
	$6,662	$496,143	$136,356	$241,435	$140,563	$34,891	$6,621	$3,663	$4,578	$1,070,913
Rockfish, copper....................	15,950	6,494	736	5,557	1,308	3,603	1,563	90	0	35,301
	$23,659	$11,970	$1,623	$13,742	$4,182	$5,633	$4,347	$90	$0	$65,247

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
ishes										
Rockfish, cowcod....................	34	0	0	464	372	1,092	238	2,524	2,085	6,809
	$17	$0	$0	$219	$248	$678	$239	$4,326	$2,912	$8,640
Rockfish, darkblotched............	860	0	0	60	339	0	0	0	0	1,259
	$46	$0	$0	$36	$339	$0	$0	$0	$0	$421
Rockfish, flag..........................	0	0	0	0	1	0	0	0	0	1
	$0	$0	$0	$0	$5	$0	$0	$0	$0	$5
Rockfish, gopher.....................	36	7,860	242	1,875	1,479	73,848	7,614	75	10	93,038
	$141	$36,182	$898	$6,631	$5,213	$250,228	$28,140	$156	$15	$327,604
Rockfish, grass.......................	659	7,379	3,484	106	6,418	32,222	8,988	0	0	59,256
	$2,967	$35,629	$13,706	$507	$30,233	$165,623	$49,261	$0	$0	$297,925
Rockfish, greenspotted...........	263	111	0	5,112	5,166	498	186	2,188	0	13,523
	$106	$54	$0	$5,241	$4,770	$424	$277	$3,113	$0	$13,984
Rockfish, greenstriped............	101	0	0	1,164	356	0	9	150	0	1,781
	$44	$0	$0	$905	$98	$0	$0	$75	$0	$1,123
Rockfish, group black/blue......	120	0	0	367	0	0	0	0	0	487
	$105	$0	$0	$344	$0	$0	$0	$0	$0	$449
Rockfish, group bolina............	25	17	6,662	54,386	3,789	42,807	1,192	0	0	108,878
	$74	$38	$16,611	$129,976	$10,038	$144,969	$4,495	$0	$0	$306,200
Rockfish, group canary/vermili	0	0	0	164	0	0	0	0	0	164
	$0	$0	$0	$148	$0	$0	$0	$0	$0	$148
Rockfish, group gopher...........	0	806	1,571	1,046	21,141	1,298	2,512	0	0	28,375
	$0	$3,333	$5,941	$3,829	$67,641	$4,162	$8,257	$0	$0	$93,163
Rockfish, group nearshore......	0	0	0	129	0	0	0	0	0	129
	$0	$0	$0	$468	$0	$0	$0	$0	$0	$468
Rockfish, group red.................	32,736	23,837	20,737	34,764	34,070	31,685	28,411	27,958	8,642	242,840
	$14,039	$9,790	$22,833	$26,306	$29,089	$47,484	$47,569	$49,071	$12,570	$258,750
Rockfish, group rosefish.........	165	47,253	10,905	103,775	164,750	82,971	20	0	0	409,839
	$338	$12,742	$2,869	$161,745	$38,193	$19,821	$8	$0	$0	$235,715

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Fishes										
Rockfish, group small.............	239,786	7,905	4,231	21,220	13,488	1,053	187	26	200	288,096
	$67,008	$3,540	$1,381	$9,762	$4,421	$698	$250	$48	$170	$87,278
Rockfish, kelp.........................	0	18	9	21	2,127	537	264	0	0	2,976
	$0	$81	$27	$21	$6,726	$1,779	$1,249	$0	$0	$9,883
Rockfish, olive.........................	623	0	0	0	23	8	215	349	0	1,218
	$690	$0	$0	$0	$24	$3	$752	$524	$0	$1,993
Rockfish, quillback..................	10,562	600	296	6,380	3	0	0	0	0	17,840
	$26,830	$2,081	$1,014	$33,930	$4	$0	$0	$0	$0	$63,860
Rockfish, redbanded...............	251	0	0	0	0	0	0	0	0	251
	$218	$0	$0	$0	$0	$0	$0	$0	$0	$218
Rockfish, rosethorn.................	286	94	0	617	40	8	60	0	0	1,106
	$433	$87	$0	$198	$12	$12	$60	$0	$0	$801
Rockfish, rosy.........................	0	0	0	500	2	0	90	0	0	591
	$0	$0	$0	$172	$1	$0	$32	$0	$0	$206
Rockfish, shortbelly.................	17,634	0	0	0	0	0	0	0	0	17,634
	$962	$0	$0	$0	$0	$0	$0	$0	$0	$962
Rockfish, speckled..................	0	0	1,482	54	0	0	0	3,439	0	4,975
	$0	$0	$1,171	$32	$0	$0	$0	$5,499	$0	$6,702
Rockfish, splitnose..................	20,793	44,448	2,847	4,761	0	0	26	1,183	5	74,063
	$4,736	$11,608	$749	$1,283	$0	$0	$15	$2,442	$0	$20,833
Rockfish, squarespot.............	0	0	0	0	23	0	0	0	0	23
	$0	$0	$0	$0	$23	$0	$0	$0	$0	$23
Rockfish, starry.......................	0	0	0	0	4	0	2,150	58	63	2,274
	$0	$0	$0	$0	$7	$0	$2,903	$106	$55	$3,070
Rockfish, swordspine.............	0	0	0	0	295	0	0	0	0	295
	$0	$0	$0	$0	$7	$0	$0	$0	$0	$7
Rockfish, treefish....................	0	0	0	0	19	1,363	573	1	5	1,960
	$0	$0	$0	$0	$90	$6,924	$2,932	$1	$19	$9,966

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ishes										
Rockfish, unspecified.............	307,887	81,483	26,930	84,285	57,544	15,019	31,520	15,404	19,547	639,619
	$129,434	$32,790	$17,274	$50,778	$39,258	$16,203	$81,249	$16,031	$27,304	$410,322
Rockfish, vermilion..................	7,027	6,837	573	4,286	2,053	424	814	4	1,270	23,287
	$9,919	$8,845	$767	$8,554	$2,777	$1,244	$1,290	$6	$1,796	$35,199
Rockfish, widow......................	501,812	288,306	259,619	164,944	101,053	73,057	373	151	336	1,389,652
	$193,213	$110,954	$123,770	$92,250	$42,834	$29,075	$1,007	$297	$269	$593,670
Rockfish, yelloweye................	12,612	5,071	222	1,471	1,289	0	0	0	0	20,666
	$22,427	$8,074	$277	$3,658	$1,566	$0	$0	$0	$0	$36,001
Rockfish, yellowtail.................	134,234	10,968	33,747	34,008	7,715	437	315	347	163	221,933
	$58,890	$3,435	$23,570	$27,845	$4,591	$268	$566	$268	$236	$119,670
Sablefish................................	1,813,892	896,817	206,018	296,075	726,326	189,201	29,108	150,858	33,791	4,342,086
	$1,649,297	$792,482	$206,311	$274,434	$673,935	$129,057	$34,585	$179,504	$83,669	$4,023,274
Salmon, Roe (Chinook and Co	0	0	55	272	0	0	0	0	0	327
	$0	$0	$55	$511	$0	$0	$0	$0	$0	$566
Salmon, chinook.....................	36,069	83,668	626,548	1,992,234	1,073,318	26,665	2,728	87	0	3,841,318
	$82,021	$183,390	$1,212,492	$3,953,433	$1,834,353	$71,702	$7,196	$151	$0	$7,344,738
Salmon, coho..........................	34	0	327	0	0	0	0	0	0	361
	$85	$0	$546	$0	$0	$0	$0	$0	$0	$631
Salmon..................................	0	0	284	168	8,896	0	0	0	0	9,348
	$0	$0	$529	$600	$23,278	$0	$0	$0	$0	$24,406
Sanddab, Pacific.....................	0	0	0	0	1,155	23,244	0	0	0	24,399
	$0	$0	$0	$0	$289	$6,023	$0	$0	$0	$6,312
Sanddab, longfin.....................	0	0	0	3	0	0	0	0	0	3
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sanddab................................	377,302	6,377	1,241	1,155,838	470,636	22,250	1,375	8,862	905	2,044,787
	$119,903	$1,998	$404	$379,998	$125,891	$5,563	$1,159	$25,600	$1,553	$662,068
Sardine, Pacific.......................	0	0	20	2,092,092	35,929,390	0	5,606,553	85,816,454	1,209,193	130,653,702
	$0	$0	$4	$81,370	$966,959	$0	$246,438	$3,613,082	$59,547	$4,967,400

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Fishes										
Sargo	0	0	0	0	0	0	0	176	0	176
	$0	$0	$0	$0	$0	$0	$0	$165	$0	$165
Scorpionfish, California	0	0	0	0	22	12	37,424	45,296	3,921	86,675
	$0	$0	$0	$0	$0	$9	$93,019	$102,382	$7,088	$202,499
Sculpin, staghorn	0	5	0	2,049	20	0	19	0	54	2,147
	$0	$0	$0	$7,087	$17	$0	$6	$0	$53	$7,163
Seabass, white	0	0	44	1,212	4,252	16,887	75,598	141,868	7,327	247,188
	$0	$0	$94	$2,419	$8,213	$38,349	$147,790	$208,960	$17,196	$423,020
Shad, American	5	0	0	0	0	0	0	0	0	5
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Shark, Pacific angel	0	0	0	0	210	6,231	46,307	560	67	53,375
	$0	$0	$0	$0	$152	$4,131	$46,010	$312	$69	$50,675
Shark, basking	0	156	0	0	0	0	0	37	0	193
	$0	$162	$0	$0	$0	$0	$0	$37	$0	$199
Shark, bigeye thresher	0	0	0	0	0	0	182	1,614	5,293	7,090
	$0	$0	$0	$0	$0	$0	$182	$1,548	$4,147	$5,877
Shark, blacktip	0	0	0	0	0	0	0	34	0	34
	$0	$0	$0	$0	$0	$0	$0	$68	$0	$68
Shark, blue	26	0	0	0	0	0	0	90	0	116
	$0	$0	$0	$0	$0	$0	$0	$23	$0	$23
Shark, brown smoothhound	0	0	0	0	4,135	0	1,186	1,312	2,886	9,518
	$0	$0	$0	$0	$2,158	$0	$709	$1,299	$1,695	$5,861
Shark, gray smoothhound	0	0	0	0	0	34	0	1,066	0	1,100
	$0	$0	$0	$0	$0	$14	$0	$1,289	$0	$1,303
Shark, horn	0	0	0	0	0	0	0	40	0	40
	$0	$0	$0	$0	$0	$0	$0	$20	$0	$20
Shark, leopard	2,997	0	131	6,632	1,137	199	6,303	6,887	1,199	25,484
	$2,997	$0	$109	$6,296	$1,074	$100	$5,328	$5,731	$1,199	$22,834

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Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
shes										
Shark, pelagic thresher	0	0	0	862	4,197	0	0	0	8,339	13,398
	$0	$0	$0	$112	$6,569	$0	$0	$0	$11,743	$18,424
Shark, salmon	278	0	0	0	0	0	0	0	0	278
	$325	$0	$0	$0	$0	$0	$0	$0	$0	$325
Shark, sevengill	30	0	50	0	0	0	41	53	0	174
	$30	$0	$25	$0	$0	$0	$14	$32	$0	$101
Shark, shortfin mako	665	0	33	71	5,480	8,624	6,047	26,641	47,086	94,646
	$656	$0	$41	$68	$6,151	$10,017	$13,798	$29,580	$54,957	$115,269
Shark, sixgill	0	0	0	168	0	0	15	25	0	208
	$0	$0	$0	$168	$0	$0	$8	$0	$0	$176
Shark, soupfin	722	661	71	6,196	8,506	3,438	26,569	24,002	28,161	98,326
	$703	$597	$74	$4,429	$8,173	$1,502	$23,485	$16,397	$29,134	$84,493
Shark, spiny dogfish	1,462	0	0	0	40,268	0	750	10,858	31	53,369
	$65	$0	$0	$0	$9,656	$0	$225	$5,182	$8	$15,135
Shark, swell	0	0	0	0	0	0	10	0	0	10
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Shark, thresher	2,102	0	21	1,004	13,046	15,335	57,716	135,716	103,475	328,415
	$1,712	$0	$41	$1,538	$20,781	$18,006	$67,486	$195,519	$157,496	$462,580
Shark, unspecified	0	209	181	1,614	9,258	99	1,556	232	205	13,354
	$0	$4	$192	$1,088	$2,630	$86	$1,124	$86	$147	$5,358
Sheephead, California	0	79	0	0	386	2,768	50,300	46,421	29,631	129,585
	$0	$0	$0	$0	$616	$5,504	$141,835	$157,159	$107,671	$412,785
Silversides	0	0	0	0	0	0	24	0	0	24
	$0	$0	$0	$0	$0	$0	$6	$0	$0	$6
Skate, California	0	0	0	99	0	0	0	0	42	141
	$0	$0	$0	$35	$0	$0	$0	$0	$21	$56
Skate, big	0	0	0	1,257	0	0	0	0	0	1,257
	$0	$0	$0	$478	$0	$0	$0	$0	$0	$478

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Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
Fishes										
Skate, thornback	0 $0	0 $0	0 $0	0 $0	24 $2	0 $0	0 $0	0 $0	0 $0	24 $2
Skate, unspecified	1,431,122 $206,731	222,020 $63,075	12,939 $2,016	54,719 $18,053	117,670 $19,000	8,141 $1,717	487 $269	23,019 $6,421	538 $269	1,870,654 $317,552
Smelt, night	540,931 $162,330	7,308 $2,196	43 $151	0 $0	39 $29	0 $0	0 $0	0 $0	0 $0	548,321 $164,706
Smelt, surf	11,580 $3,536	119 $54	0 $0	28 $21	7 $3	0 $0	2 $1	0 $0	0 $0	11,736 $3,614
Smelt, whitebait	1,371 $192	0 $0	0 $0	0 $0	148 $96	0 $0	0 $0	0 $0	0 $0	1,519 $288
Smelts, true	0 $0	0 $0	0 $0	0 $0	0 $0	0 $0	5 $1	1,789 $716	0 $0	1,794 $717
Sole, Dover	3,603,476 $1,322,468	1,563,704 $782,921	536,214 $161,454	648,072 $187,534	1,081,154 $311,836	984,563 $329,140	197 $164	107 $177	11 $12	8,417,498 $3,095,706
Sole, English	348,670 $122,034	144,296 $121,649	29,475 $10,659	205,819 $80,349	102,305 $34,643	18,995 $7,105	275 $110	0 $0	0 $0	849,836 $376,549
Sole, butter	49 $7	0 $0	0 $0	6 $7	0 $0	0 $0	0 $0	0 $0	0 $0	55 $13
Sole, fantail	0 $0	0 $0	0 $0	629 $404	0 $0	55 $52	0 $0	0 $0	0 $0	684 $456
Sole, petrale	671,920 $588,385	155,719 $161,868	46,129 $46,927	191,614 $205,223	145,691 $141,773	35,715 $40,328	3,024 $2,998	113 $65	2 $2	1,249,926 $1,187,558
Sole, rex	290,952 $112,279	157,596 $68,187	28,198 $10,970	58,406 $22,780	68,653 $25,010	25,266 $9,957	39 $6	343 $166	0 $0	629,453 $249,356
Sole, rock	0 $0	906 $343	268 $139	12,577 $5,530	757 $356	0 $0	0 $0	0 $0	0 $0	14,508 $6,369
Sole, sand	10,129 $7,491	0 $0	1,015 $704	43,021 $36,512	4,789 $1,599	956 $782	0 $0	0 $0	225 $0	60,134 $47,089

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Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
Fishes										
Sole, tongue	0	0	0	0	0	0	21	0	0	21
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sole, unspecified	0	2	25	342	39	890	8,835	22,508	99	32,740
	$0	$2	$20	$192	$39	$1,207	$6,878	$12,906	$137	$21,382
Stickleback, threespine	0	0	0	254	0	0	0	0	0	254
	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Stingray	0	0	0	0	0	0	0	1,383	0	1,383
	$0	$0	$0	$0	$0	$0	$0	$345	$0	$345
Surfperch, barred	139	0	2,009	0	0	7,414	0	0	0	9,562
	$160	$0	$1,899	$0	$0	$12,679	$0	$0	$0	$14,738
Surfperch, black	0	0	0	0	0	1	27	4	10	42
	$0	$0	$0	$0	$0	$0	$14	$4	$50	$69
Surfperch, pile	499	0	0	0	0	0	0	6	0	505
	$568	$0	$0	$0	$0	$0	$0	$10	$0	$578
Surfperch, rainbow	0	43	0	0	0	1	0	0	0	44
	$0	$174	$0	$0	$0	$0	$0	$0	$0	$174
Surfperch, redtail	29,671	118	0	0	8	1	0	0	0	29,798
	$33,283	$129	$0	$0	$6	$1	$0	$0	$0	$33,420
Surfperch, rubberlip	0	0	0	18	0	0	35	261	0	314
	$0	$0	$0	$27	$0	$0	$23	$313	$0	$362
Surfperch, unspecified	584	58	613	2,408	36	1,712	742	188	252	6,593
	$800	$82	$737	$5,267	$45	$3,062	$515	$276	$233	$11,018
Surfperch, white	153	0	0	2,385	0	0	0	0	0	2,538
	$191	$0	$0	$7,287	$0	$0	$0	$0	$0	$7,479
Swordfish	26,317	0	2,297	58,763	236,171	203,852	64,193	1,846,875	614,443	3,052,910
	$74,136	$0	$7,851	$116,240	$564,682	$604,489	$195,588	$4,639,141	$2,005,515	$8,207,641
Thornyhead, longspine	1,034,726	413,050	92,956	134,912	379,851	291,697	7,695	22,028	3,284	2,380,198
	$803,791	$311,950	$67,070	$88,771	$434,545	$216,708	$11,224	$28,348	$8,468	$1,970,876

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
Fishes										
Thornyhead, shortspine..........	328,973	133,001	34,007	42,103	112,293	88,299	6,558	26,412	10,258	781,904
	$355,291	$133,961	$26,618	$35,210	$141,828	$67,109	$18,845	$48,530	$31,915	$859,307
Thornyheads..........................	24,493	32,757	6,510	14,033	8,782	0	5,998	38,507	406	131,487
	$22,956	$31,046	$5,541	$10,704	$6,336	$0	$10,712	$91,418	$1,291	$180,004
Tomcod, Pacific......................	2,045	0	0	0	0	0	0	0	0	2,045
	$205	$0	$0	$0	$0	$0	$0	$0	$0	$205
Triggerfish..............................	0	0	48	0	0	0	0	0	0	48
	$0	$0	$133	$0	$0	$0	$0	$0	$0	$133
Tuna, albacore........................	603,348	64,761	62,096	178,054	1,139,895	319,493	42,318	7,597,019	2,286,133	12,293,117
	$532,447	$61,026	$71,432	$146,745	$772,862	$197,946	$58,681	$6,616,353	$1,687,911	$10,145,403
Tuna, bigeye..........................	0	11	0	7,737	10,481	5,842	0	165,240	22,907	212,218
	$0	$44	$0	$23,211	$36,225	$18,737	$0	$464,183	$88,083	$630,484
Tuna, bluefin..........................	2,118	0	270	3,188	236,733	11,670	3,596	32,440	74,493	364,508
	$5,380	$0	$1,057	$6,887	$441,561	$31,182	$7,636	$179,850	$382,897	$1,056,450
Tuna, skipjack, black.............	0	0	0	2,171	0	0	15	194,249	873	197,308
	$0	$0	$0	$0	$0	$0	$23	$56,585	$2,054	$58,662
Tuna, skipjack........................	0	0	0	80	0	0	809	8,284,563	586	8,286,038
	$0	$0	$0	$103	$0	$0	$1,171	$2,746,425	$478	$2,748,176
Tuna, unspecified....................	1,107	7	0	0	4,211	0	32	17,516	1,789	24,662
	$1,360	$27	$0	$0	$9,707	$0	$37	$47,564	$956	$59,652
Tuna, yellowfin.......................	216	0	0	45	524	1,775	32	2,977,459	1,128	2,981,179
	$238	$0	$0	$81	$464	$1,143	$120	$1,425,477	$2,011	$1,429,533
Turbot, curlfin.........................	0	0	0	0	0	0	0	90	0	90
	$0	$0	$0	$0	$0	$0	$0	$68	$0	$68
Turbot....................................	4,161	49	201	3,101	401	101	0	0	6	8,020
	$1,440	$20	$71	$1,134	$259	$31	$0	$0	$7	$2,962
Wahoo....................................	0	0	0	0	0	0	0	3,690	471	4,161
	$0	$0	$0	$0	$0	$0	$0	$2,833	$1,270	$4,102

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
;hes										
Nhitefish, ocean	0 $0	0 $0	0 $0	0 $0	0 $0	1 $3	9,320 $19,294	1,371 $1,930	475 $332	11,168 $21,559
Nhiting, Pacific	2,881,997 $115,257	0 $0	0 $0	4 $0	957 $314	0 $0	53 $15	3 $0	0 $0	2,883,014 $115,587
'ellowtail	0 $0	0 $0	0 $0	106 $107	0 $0	0 $0	10,945 $17,826	42,485 $45,306	12,639 $14,642	66,175 $77,880
ustaceans										
;rab, Dungeness	7,113,759 $13,095,046	632,570 $1,266,716	362,385 $970,031	578,583 $1,592,946	25,027 $74,729	1,521 $4,268	21 $63	0 $0	0 $0	8,713,865 $17,003,798
;rab, box	0 $0	0 $0	0 $0	30 $44	0 $0	0 $0	808 $1,382	5,782 $6,057	89 $178	6,709 $7,661
;rab, brown rock	0 $0	0 $0	929 $557	0 $0	0 $0	0 $0	0 $0	0 $0	0 $0	929 $557
;rab, claws	0 $0	0 $0	0 $0	0 $0	308 $719	0 $0	1,213 $1,307	1,684 $1,403	143 $715	3,347 $4,144
;rab, king	0 $0	0 $0	0 $0	0 $0	0 $0	23 $34	415 $758	0 $0	46 $113	483 $904
;rab, pelagic red	0 $0	0 $0	0 $0	0 $0	0 $0	0 $0	2 $0	0 $0	0 $0	2 $0
;rab, red rock	0 $0	0 $0	1,279 $1,023	0 $0	0 $0	10 $9	10 $9	0 $0	9 $14	1,308 $1,055
;rab, rock unspecified	10,527 $17,389	0 $0	1,364 $1,089	48,953 $55,147	21,136 $26,076	93,045 $117,238	504,907 $643,255	47,956 $68,588	62,549 $75,450	790,437 $1,004,231
;rab, sand	0 $0	0 $0	0 $0	0 $0	0 $0	0 $0	0 $0	65 $130	0 $0	65 $130
;rab, shore	0 $0	0 $0	0 $0	900 $0	23 $29	0 $0	0 $0	0 $0	3 $6	926 $35
;rab, spider	0 $0	0 $0	0 $0	0 $0	3 $3	570 $490	30,763 $25,151	23,911 $26,510	13,354 $8,373	68,601 $60,527

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
Crustaceans										
Crab, tanner	0	0	0	256	0	6	0	0	0	262
	$0	$0	$0	$896	$0	$13	$0	$0	$0	$909
Crab, yellow rock	0	0	0	0	0	0	297	5	0	302
	$0	$0	$0	$0	$0	$0	$448	$0	$0	$448
Crayfish, unspecified	0	0	88,903	0	0	0	0	184	19	89,106
	$0	$0	$100,163	$0	$0	$0	$0	$92	$37	$100,292
Crustacean, unspecified	0	0	0	0	34	904	0	0	0	938
	$0	$0	$0	$0	$34	$265	$0	$0	$0	$299
Lobster, California spiny	0	0	0	0	0	198	184,018	170,231	138,896	493,343
	$0	$0	$0	$0	$0	$1,683	$1,430,629	$1,198,341	$1,062,119	$3,692,772
Prawn, golden	0	0	0	0	25	0	0	0	0	25
	$0	$0	$0	$0	$194	$0	$0	$0	$0	$194
Prawn, ridgeback	0	0	0	600	264	2,314	1,385,858	3,151	184	1,392,370
	$0	$0	$0	$420	$792	$3,840	$1,689,287	$3,127	$752	$1,698,218
Prawn, spot	1,255	6,327	17,023	75,867	52,980	126,000	204,302	92,750	36,625	613,129
	$7,983	$43,268	$121,853	$501,926	$374,011	$882,126	$1,338,209	$715,549	$268,686	$4,253,611
Shrimp, Pacific Ocean	3,581,747	318,623	56,062	96	1,016	278,024	6,176	0	0	4,241,744
	$1,655,845	$122,344	$28,031	$27	$3,025	$195,521	$4,804	$0	$0	$2,009,598
Shrimp, bay	0	0	0	98,086	0	0	0	0	0	98,086
	$0	$0	$0	$337,839	$0	$0	$0	$0	$0	$337,839
Shrimp, brine	0	0	0	1,391,470	0	0	0	0	0	1,391,470
	$0	$0	$0	$4,550	$0	$0	$0	$0	$0	$4,550
Shrimp, coonstriped	75,540	0	0	0	0	0	0	0	0	75,540
	$312,906	$0	$0	$0	$0	$0	$0	$0	$0	$312,906
Shrimp, ghost	0	0	0	0	0	0	0	0	421	421
	$0	$0	$0	$0	$0	$0	$0	$0	$6,372	$6,372
Shrimp, red rock	0	0	0	0	0	0	0	308	0	308
	$0	$0	$0	$0	$0	$0	$0	$6,350	$0	$6,350

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
'ustaceans										
Shrimp, unspecified	0	0	33	0	0	0	971	970	81	2,054
	$0	$0	$195	$0	$0	$0	$2,091	$1,210	$307	$3,803
:hinoderms										
Cucumber, sea	0	110	4,999	0	46	0	428,946	137,658	29,117	600,875
	$0	$66	$3,677	$0	$46	$0	$347,200	$85,377	$15,452	$451,818
Sea stars	0	0	0	0	0	0	1,828	0	303	2,131
	$0	$0	$0	$0	$0	$0	$548	$0	$0	$548
Urchin, purple sea	0	22,880	0	0	0	0	5,409	1,358	150	29,797
	$0	$15,538	$0	$0	$0	$0	$4,525	$2,535	$203	$22,801
Urchin, red	36,532	2,647,507	467,796	27,194	0	6,274	7,660,236	2,750,075	581,827	14,177,441
	$26,437	$1,960,416	$339,605	$6,952	$0	$7,944	$7,783,115	$2,635,671	$488,217	$13,248,356
Urchin, white	0	0	0	0	0	0	0	2,250	0	2,250
	$0	$0	$0	$0	$0	$0	$0	$1,570	$0	$1,570
ɔllusks										
Clam, California jackknife	0	0	0	0	0	0	0	1,152	0	1,152
	$0	$0	$0	$0	$0	$0	$0	$2,584	$0	$2,584
Clam, northern quahog	0	0	0	0	0	0	0	110	0	110
	$0	$0	$0	$0	$0	$0	$0	$33	$0	$33
Clam, rosy razor	0	0	0	0	0	0	0	17	0	17
	$0	$0	$0	$0	$0	$0	$0	$35	$0	$35
Clam, unspecified	0	0	0	0	0	0	1	40	0	41
	$0	$0	$0	$0	$0	$0	$0	$90	$0	$90
Limpet, unspecified	0	0	0	0	0	0	21	225	35	281
	$0	$0	$0	$0	$0	$0	$19	$630	$8	$657
Mussel	0	0	0	0	0	0	135	6,970	0	7,105
	$0	$0	$0	$0	$0	$0	$67	$4,453	$0	$4,520
Octopus, unspecified	2,558	251	415	1,393	1,554	37	562	825	3	7,598
	$838	$135	$308	$1,075	$1,596	$1	$265	$928	$0	$5,146

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Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
Mollusks										
Sea hare	0	0	0	0	0	0	0	15	5	20
	$0	$0	$0	$0	$0	$0	$0	$90	$0	$90
Sea slug	0	0	0	0	0	0	0	130	0	130
	$0	$0	$0	$0	$0	$0	$0	$293	$0	$293
Snail, freshwater	0	0	0	0	2,940	0	0	0	0	2,940
	$0	$0	$0	$0	$3,812	$0	$0	$0	$0	$3,812
Snail, sea	0	0	0	0	0	691	471	2,701	313	4,176
	$0	$0	$0	$0	$0	$391	$236	$1,074	$142	$1,843
Snail, top	0	0	0	0	0	0	110	1,671	22,495	24,276
	$0	$0	$0	$0	$0	$0	$50	$657	$9,027	$9,733
Snails, moon	0	0	0	0	0	29	0	1,961	0	1,990
	$0	$0	$0	$0	$0	$8	$0	$664	$0	$672
Squid, jumbo	174	0	0	0	170	55	1	13,502	0	13,902
	$46	$0	$0	$0	$298	$8	$0	$4,459	$0	$4,810
Squid, market	12	0	0	11,800	588,960	39,512	140,309,133	60,803,756	9,000	201,762,172
	$6	$0	$0	$1,770	$78,579	$5,330	$23,655,780	$9,035,065	$4,500	$32,781,029
Whelk, Kellet's	0	0	0	0	1,369	254	29,775	10,146	2,234	43,779
	$0	$0	$0	$0	$9,583	$145	$16,342	$4,775	$1,662	$32,508
Amphibians										
Frog	0	0	0	0	342	0	0	0	0	342
	$0	$0	$0	$0	$1,026	$0	$0	$0	$0	$1,026
Worms										
Invertebrates, colonial	0	0	0	0	0	0	0	0	203	203
	$0	$0	$0	$0	$0	$0	$0	$0	$812	$812
Lancelets, amphioxus	0	0	0	0	0	0	0	255	0	255
	$0	$0	$0	$0	$0	$0	$0	$1,210	$0	$1,210
Spiders, sea	0	0	0	0	2	0	0	0	0	2
	$0	$0	$0	$0	$2	$0	$0	$0	$0	$2

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Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Eureka	Fort Bragg	Bodega Bay	San Francisco	Monterey	Morro Bay	Santa Barbara	Los Angeles	San Diego	Total Landings
'orms										
Tunicates................................	0	0	0	0	0	0	0	3	0	3
	$0	$0	$0	$0	$0	$0	$0	$15	$0	$15
Worms, marine........................	0	0	0	0	0	0	0	20	0	20
	$0	$0	$0	$0	$0	$0	$0	$41	$0	$41
Grand Total Pounds:	27,066,799	9,192,763	3,551,971	16,260,034	47,466,202	3,651,088	162,756,368	196,603,804	5,673,632	472,222,661
Grand Total Value:	$22,428,898	$7,356,270	$3,968,162	$12,267,349	$8,534,437	$4,618,894	$39,913,152	$37,254,804	$6,985,984	$143,327,950

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End of Report

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Table 15a - Poundage And Value Of Landings Of Commercial Fish Into California By Area - 1999

Species	Sacramento Delta	Inland Waters	Unknown or Invalid Ports	Total Landings
Fishes				
Kelpfish, giant	50	0	0	50
	$5	$0	$0	$5
Shad, threadfin	52,858	0	0	52,858
	$43,939	$0	$0	$43,939
Crustaceans				
Crab, yellow rock	20	0	0	20
	$20	$0	$0	$20
Crayfish, signal	350	0	0	350
	$663	$0	$0	$663
Crayfish, unspecified	95,837	0	0	95,837
	$57,143	$0	$0	$57,143
Shrimp, brine	0	1,025	123,734	124,759
	$0	$0	$11	$11
Grand Total Pounds:	149,115	1,025	123,734	273,874
Grand Total Value:	$101,770	$0	$11	$101,781

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End of Report